COLONY AND PROTECTORATE OF KENYA

DEPARTMENT OF AGRICULTURE
ANNUAL REPORT
1959

Volume II—Record of Investigations

Sh. 7/50 - 1961

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DEPARTMENT OF AGRICULTURE

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INTRODUCTION BY THE CHIEF RESEARCH OFFICER

A general account of the work of the Department of Agriculture in 1959, including that of the Research Division, has already been published as Volume I. In Volume II, entitled "Record of Investigations", an account of the Department's research work is given in greater detail. This volume is intended for the reader who wishes to follow the work in progress more closely, and references to other published information and in most cases to stations where the work is being carried out are supplied. A serious reader can therefore follow up development in any particular field which interests him by referring to other publications or making contact with the stations themselves.

Volume II has been published as a separate volume since 1949. Its publication in the present form has made it possible for Volume I to appear more quickly because, with some crops, experimental yield data are not available in final form until after the end of the calendar year and the compilation of the more detailed reports presented here does not therefore hold up publication of the Department's general annual report which must appear as soon as possible after the end of the year of reporting. In addition, the present system avoids the risk of confusing the general public by inclusion of too much detail in Volume I. It must also be recognized that the Colony's agricultural research effort has expanded rapidly since the war with a consequent increase in the annual accumulation of information of interest and value to the agricultural industry. This factor in itself has enhanced the need for separate publication.

By 1955, Volume II had grown in size to such an extent that it became necessary for reasons of economy to make a serious attempt to limit its size and a brief description of the manner in which this was achieved is necessary. Where research sections of the Department have special arrangements to publish full and detailed independent annual reports only a very brief account of their work is published in the present volume. Cases in point are the Annual Report of the Coffee Research Station, Ruiru, which is published by the Coffee Board of Kenya; the Annual Report of the Pyrethrum Research Station, Molo, which is published by the Pyrethrum Board of Kenya; and the Annual Report of the High Level Sisal Research Station, Thika, which is published by the Kenya Sisal Board. Copies of these reports can be obtained from the organizations mentioned or the officers in charge of the Research Stations themselves. In all branches every possible effort is made to see that completed work is published in the farming press and scientific journals and very brief mention of such work is all that is then necessary in this volume. Reference to such publications is given and interested readers can refer to the appropriate publications of which reprints are frequently available upon application to the Librarian at the Department's headquarters in Nairobi. In addition, reporting officers are under orders not to include in the present volume long and detailed descriptions of work which is proceeding, but which is not yet showing results of interest and importance. Such items receive only brief mention to indicate for the sake of completeness that work is being done on them.

By adopting these measures it has been possible to keep within the limited size allowed, and at the same time to present in reasonable detail information of value to farmers and other scientists which might otherwise have perforce received very inadequate cover. Volume II thus ensures an adequate general

cover of all work in progress in the research field, but its most important function is to ensure that information which for one reason or another may never be published in any other form is in fact recorded in print. This is a matter of the utmost importance. The value of departmental annual reports as a source of information in later years has been conclusively demonstrated on many occasions; in fact they are sometimes the only source of such information. It is thus the intention to continue the publication of Volume II in the confident knowledge that the material presented will be of undoubted value to farmers, scientific workers elsewhere and to our own officers.

Farmer members of research committees have on occasion made the comment that current items of investigation have to their knowledge been fully examined at some previous date and express concern that investigations have to be repeated. Frequently there are good reasons why the work must be repeated, such as, for example, the present existence of more accurate evaluation techniques, but it is also true to say that the system of recording work in some cases in the past left a lot to be desired and records have been lost.

In such cases back numbers of the Department's annual reports may contain the only reference to work done. There were, of course, exceptions and well-preserved archives exist in some stations. In general there has been a great improvement in the systematic recording of results of experimental work on stations and a comprehensive system of recording was introduced centrally in 1951.

Steps are now being taken to improve these arrangements still further by the introduction of a modern recording system which will cover all stations. When this system is in full operation it may prove possible to make further changes in the form of this volume. In the meantime it is considered that the publication of Volume II meets an essential need.

In introducing the present report the following brief comments on the highlights of the year are submitted:—

A new post of Agricultural Research Officer (Engineering) was established at the beginning of the year and a report from this section appears for the first time. This section is based at Nakuru and the officer-in-charge maintains liaison with the East African Tractor and Implement Testing Unit which is also based at Nakuru. The intention is that this officer shall advise all sections of the Department on agricultural machinery matters and carry out special development projects as necessary. The usefulness of this appointment is already very apparent and a full programme of work is in hand. The coffee and sisal industries have taken full advantage of this new section and financial support has been provided for certain special projects.

A grant from the Colonial Development and Welfare Fund has made it possible to plan and initiate additional work on the pathology of black stem rust of wheat at the Plant Breeding Station at Njoro and to embark upon a long-term maize improvement programme for Western Kenya which is based on Kitale and Kakamega. Work initiated in the first phase of this programme, in anticipation of funds being obtained to support the full programme, is already showing very encouraging results. At Katumani, Machakos, Taboran maize proved its worth in a severe drought by yielding a crop, whereas the local white type virtually failed.

In liaison with the other East African territories a great deal of effort has been put into improving measures aimed at excluding the stored products pest, *Trogoderma granarium*. Under coastal conditions B.H.C. has been found to be ineffective in controlling insect infestations of cereals when used at legally

permitted rates, but malathion shows considerable promise when admixed with the grain. Aluminium phosphide tablets are proving of great value for fumigating various cereals. Already the storage problems of the warmer parts of the country have benefited greatly from this new programme. Research on pyrethrum thrips and the *Nematocerus* weevil on wheat is receiving priority. *Eretmocerus serius*, a parasite of the Citrus Black Fly (*Aleurocanthus woglumi*), was introduced to Coast Province and is now firmly established there. Promising results are being obtained with biological control of Prickly Pear (*Opuntia*) following the introduction of *Dactylopius tomentosus*. The Lantana Seed Fly (*Agromyza lantanae*) now appears to be established all over the Colony and is thought to be a considerable factor in preventing spread by seed. The Lantana Lace-bug (*Teleonemia scrupulosa*) is having some effect on the plant at the coast. The Colonial Development and Welfare project on Coccid Taxonomy has been extended by a further grant and the publication of valuable scientific papers continues.

Soil survey work continued through part of the year under Dr. James Thorp. 20,000 acres of general farm land was surveyed at Sotik and an area north of Meru was surveyed for suitability for tea development. In addition, a number of areas in the Uaso Nyiro catchment were surveyed with a view to assessing their irrigation potential. The Solai survey is being continued by the Department's own surveyor. Dr. Thorp himself concentrated mainly on a study of Kenya soils with a view to publishing a general account of them and to developing a framework for their classification.

In the Soil Science field of work, Dr. Mehlich left Kenya in July at the end of a very stimulating tour of duty. The rapid soil test procedures which he developed have led to a greatly enhanced capacity for soil examination at the Scott Agricultural Laboratories and he was in addition able to give preliminary consideration to the field interpretation of his laboratory findings.

We are most grateful to the International Co-operation Administration of the U.S.A. for the valuable assistance which this Soils Team has given us. The work will be published in full partly from Kenya funds and partly from a Colonial Development and Welfare grant.

Very encouraging progress continues to be made on bioassay of soils and new laboratory accommodation and a greenhouse have been provided for this work.

The programme of fertilizer trials in African areas of the Colony is producing a clear picture of the future direction in which this work must go and already a great deal of information is available which can be applied in the field. Good progress can be recorded in the Biochemist's wheat studies, especially in connexion with the electrophoretic separation of gluten proteins. This and his work on wheat maturation form an important part of a wider research programme on the general question of wheat baking quality.

The Plant Pathology Section has undertaken valuable work on seed dressings and it is clear that farmers in general have much to gain from proper use of these. Information has been supplied in the farming press in co-operation with the Entomological Section. Work on eelworms attacking a wide range of crops has been initiated and the menace that these organisms can be to agriculturalists has been fully recognized.

In coffee research, results accruing from the Colony-wide series of variety trials are proving of great value in connexion with the expansion of the crop in African areas and elsewhere. The problems of coffee nutrition have been given special attention over a long period and the quality of advice available

to growers has now reached a very high level. The foliar analysis research programme is now under way. The Coffee Pathologist has devoted a great deal of attention to the problem of stem pitting and research on this problem, of general East African interest, is making good progress. Revised recommendations have been issued for controlling current coffee pests and of particular interest is the introduction of a method of controlling *Antestiopsis* in African coffee in which pyrethrum is used to achieve rapid "knock down" and 5 per cent D.D.T. dust applied to tree stumps ensures that insects which have been knocked down do not recover and re-enter the tree.

The Coffee Berry Disease Research Unit has received a further grant from the Colonial Development and Welfare Fund. This Unit also now conducts research on Leaf Rust (*Hemileia vastatrix*). While very useful progress continues to be made on both diseases the highlight of the year has been the demonstration that the movement of the causal organism is mainly brought about by rain-splash. This fact is likely to have a profound influence on the future approach to the problem of control.

The Grassland Research Team has made notable advances during the year. Leafier and more vigorous strains of Rhodes Grass and *Setaria* have been selected and new knowledge on the breeding behaviour of various grasses and clovers obtained. Great importance is being attached to the problem of management of grass. The contribution of the Department to the development of a sound trade in herbage seeds is having a valuable effect. The work at the high-altitude station at Molo is making excellent progress and a successful effort is being made to carry the work to a practical conclusion on the main part of the farm. At Katumani the Pasture Research Officer is concerned with management of natural grassland, fodder crops, bush control and ley farming under semi-arid conditions, while at Marigat, bush control, reseeding of denuded areas under arid or semi-arid conditions, the acquisition of knowledge on the preservation of natural ground cover which enables sound advice to be given to grazing schemes, are the main concerns of the Pasture Research Officer there. Particular attention is drawn to the work of the Pasture Research Chemist, because his work, much of which is original in a world-wide sense, is proving of inestimable value in the broad understanding of plant/animal relationships. It forms, in fact, an indispensable part of the programme of animal husbandry problems under investigation in the widest possible sense.

Work continues on a wide range of horticultural crops and this section of the division is probably more concerned than any other with research on marketing of its products, both locally and on overseas markets.

In an effort to speed up the use of improved planting material of pyrethrum, seed production of improved varieties has been increased. Good progress has been maintained in the plant breeding programme. Results of fertilizer trials continue to indicate the need for phosphate on the more reddish and leached soils and it would pay many farmers to use more phosphate fertilizer on this crop.

Experiments on picking methods have shown clearly that flowers should be stripped down to flowers with vertical petals at two-weekly intervals to achieve the highest yield of pyrethrins per acre.

In sisal research dalapon continues to show great promise as a means of controlling couch grass. Increased attention has been paid to getting research results across to growers and very good progress in this direction can be reported.

On irrigation schemes generally the planning of research has become somewhat easier as a result of a clearer picture being available on field development.

At Mwea/Tebere the search for new cash crops especially for the red soils continues. Both here and at Perkerra and Galole onions have every appearance of becoming a satisfactory crop. At Galole cotton is the main cash crop and cattle for beef and milk are under trial on Star Grass pastures at Perkerra.

On general investigation stations in the African areas work has continued on a wide range of problems concerning food and cash crops. The priorities vary from one part of the country to the other because the programmes are very closely related to the agricultural developments taking place locally, and it is encouraging to record that the essential links between research and application in the field are steadily becoming stronger. Good progress can be recorded in the field of animal husbandry. While considerable accent is being placed on the development of cash crops to improve the economy and standard of living, great importance is attached to work on food crops. In particular the need to improve the diet of the people especially in respect of protein is regarded as being of the utmost importance.

In areas where European mixed farming is practised work on possible alternative crops continues and Soya Beans and White Gram are showing promise in the Trans Nzoia. Elsewhere prospects for the development of the potato crop are good. The main accent has been on ley farming and problems connected with the conversion of grass and other crops into animal products. Special mention must be made of a preliminary feeding trial with Jersey cattle at Kitale which has yielded much information and experience of value. This is being followed by a further trial of similar design. The main problem at present appears to be the need to improve protein production in the herbage and this is now receiving special attention.

A very satisfactory flow of scientific and advisory literature has been produced by all branches of the Research Division and very good progress in getting results across to farmers of all races can be recorded. The Research Committees continue to perform a most valuable function and once again it is a pleasure to take this opportunity to thank all those farmers who give up so much time to help these committees to function.

I would like to express our gratitude to the various organizations who help us with finance for research and would specially mention the Colonial Development and Welfare Fund, the International Co-operation Administration of the U.S.A., the Rockefeller Foundation and various producer bodies, notably the Coffee Board of Kenya, the Pyrethrum Board of Kenya, the Kenya Sisal Board and the Cereals Producers Board.

I should like to thank Sir. G. W. Nye, K.C.M.G., O.B.E., Mr. G. M. Roddan, C.M.G., and Mr. D. Rhind, O.B.E., for their continual interest in our problems and for all the help they give us. In the past year we have had very valuable visits from various members of the staff of the Tropical Products Institute in London and have received valuable and willing assistance over a wide field of activities. I should like to mention especially the visits of Dr. E. C. Stakman of the University of Minnesota, who came to Kenya to advise us on our plant breeding and rust research work with wheat. This was a very stimulating visit and we are grateful to the Rockefeller Foundation for making it possible.

Finally I should like to thank all officers of the Research Division for another fine year of achievement.

A. R. MELVILLE,
Chief Research Officer.

29th August, 1960.

ANNUAL REPORT OF THE SENIOR ENTOMOLOGIST, 1959

Entomologists were stationed at Kibos to deal with insect pest problems in Nyanza, at Nakuru to deal with the Rift Valley Province, and at Matuga to work on pests of the Coast Province. A stored products entomologist was stationed at Kilindini to study pests of ships' cargoes and of stored grain.

At the Scott Agricultural Laboratories work consisted of elimination of pests of stored maize, coccid taxonomy, plant protection, advisory work and on the administration of the entomological services. The coffee entomologist at Ruiru submits his annual report with those of the rest of the Coffee Research team.

Plant Protection Services

Further progress towards uniformity of action with the other East African territories was made at meetings of the Standing Technical Committee on Plant Import and Export, and at a special meeting held at Mombasa.

Importation of Plants

Parcels inspected through the Post Office totalled 841 as compared with 1,584 in 1958 and 2,520 in 1957. This points to less importations by individuals but not necessarily to a decline in imports since bulk consignments by seedsmen would not come by post.

Similarly there was a decline in Plant Importation Permits; 1,511 were issued as compared with 1,544 in 1958 and 1,812 in 1957. Air freight consignments totalled 217, plus further consignments brought in by air passengers.

Export of Plant Material

Phytosanitary certificates issued for outgoing consignments totalled 299, an increase of 13 over 1958 and 70 over 1957.

Fumigations

Only 14 fumigations with hydrocyanic acid gas were carried out.

The helpful co-operation of the staff of H.M. Customs and Excise, the General Post Office and the East African Airways Corporation is gratefully acknowledged.

Stored Products

The Pest Infestation of Stored Products Committee held two meetings during the year. A subject, widely discussed, was the formation of a Stored Products team to work on an increased range of stored products. This, however, has not met with wide support and the scheme has had to be shelved in spite of heavy losses incurred between harvesting and the consumption of the crop.

Present staff consists of S. P. L. Kockum and W. M. Graham (both employed by the Maize Marketing Board) and F. Ashman (Department of Agriculture). They report as follows:—

Very little work was done on methyl bromide fumigations of large stacks since the major problems have now been solved. Reports were received of "fumigation failures" of export maize, but it was shown that the cause of trouble was the extreme rapidity of reinfestation by *Tribolium* under Coast conditions.

Two large stack experiments using polyethylene covers to prevent reinfestation were completed in Nairobi and Kisumu, and although a slight reinfestation was not prevented the results were very satisfactory. The overall infestation and degree of damage was much less in polyethylene covered stacks, while moth infestation was completely prevented. An equally important saving was related to the prevention of drying. No danger of moulding occurred yet about 1 per cent of the weight of maize was saved through moisture conservation.

A stack dusted with 1 per cent lindane in diatomite at a rate of 2 oz. per bag was as badly damaged after five months as was an untreated control stack. The recommendation for dusting layers of maize has therefore been withdrawn.

In the Central Province much produce has had lindane dust admixed during the past two years. Since earlier work has shown admixing to be highly effective, we have planned to emphasize this aspect of work in the future. Experiments will involve malathion as well as lindane dusts.

A large 13-month crib experiment was completed. It was found that coumarone resin added to lindane in kerosene was not superior to lindane alone when sprayed on the hessian outer wall lining. The degree of weevil control was related to position in the crib and to moisture content. Recommendations arising out of the experiment have not yet been given.

Temperature studies have been made of the interior of large experimental stacks, and have proved a valuable tool in assessing the degree of infestation. A large sack sieve has been used to get a more accurate count of infesting insects and comparisons are being made of the reliability of the results obtained by different sample sizes. The most promising sampling method for large stack or bag experiments in assessing infestation and damage is the weight of dust per bag.

At the coast, liaison with the Chief Grader and his staff was maintained on all entomological problems. Ship inspections were carried out at the request of the Chief Grader or any other organization. Ten ship inspections were made and details were recorded: the use of the sack sieve mentioned above facilitated inspections. Contact with the Chief Entomologist, Ministry of Agriculture, Fisheries and Food, was maintained, and a useful exchange of information with the Tropical Liaison Officer of the Agricultural Research Council took place.

Two outbreaks of *Trogoderma granarium* were reported this year in East Africa, both of them in Dar es Salaam. These were eradicated. A report on their possible origin was drawn up. Up-country wheat stores were inspected twice during the year at the request of the Wheat Board and recommendations were made for store hygiene and the application of control measures to eliminate insect pests. Some farms were visited and their wheat stores examined. The standard of storage was very variable and there is room for much improvement. The need for isolating newly harvested wheat from old seed wheat and insect-infested foodstuffs is not always recognized. The use of a toxic fumigant, aluminium phosphide, was demonstrated and this may prove of great value to the wheat industry in that small consignments *Calandra oryzae* weevils can be dealt with under simple conditions. Storage of cereals on farms in the Coast Province has been investigated and it has been found that B.H.C. is ineffective in preventing insect infestation when used at the legally permitted rates. Malathion, on the other hand, shows promise when admixed with grain, but not as a general surface spray in stores. Reinfestation by *Tribolium castaneum* and *Ephestia cautella* continues to take place in spite of the use of dusts and wettable powders of malathion applied to the outside of grain stacks. The admixture of malathion which has proved successful was at a rate of eight parts per million, i.e. that recommended by the Colonial Code of Practice.

Pests of Agriculture

The *Nematocerus* weevil attacking wheat and barley in the Naro Moru area continued to be a major pest. In the tea nurseries of Sotik continual baiting of the adults seems to have reduced numbers and lessened the damage caused by the grubs to the tea roots. This baiting with B.H.C. is, however, difficult of application to large acreages of arable land.

A trial using heavy soil applications of toxaphene, dieldrin, heptachlor and B.H.C. was laid down on a farm in the Aberdares, but results are not yet available. Such a treatment, if successful, will prove expensive unless the insecticides can persist in the soil for several years.

Rice Stem borers (*Maliarpha separatella* and *Sesamia calamistis*) continue to occur in rice fields but without causing any serious damage and control measures did not appear to be necessary. Small attacks of mite occurred on mature tea in the Karatina District, but these subsided without control measures having to be taken. In peasant agriculture such mite attacks appear to be controlled by natural enemies: the application of insecticides on the other hand may have serious repercussions by eliminating natural enemies.

Entomological Investigations—Coast Province

Mr. Wheatley, Entomologist, Coast Province, writes as follows:—

Coreid Bug Coconuts (*Pseudotheraptus wayi*)

Bioassay work with *Pseudotheraptus* has been completed and a paper is being written. A small machine specifically designed for hand-spraying coconuts has been developed in co-operation with Long Ashton Research Station, Bristol. A large-scale spraying trial with 24 of these machines involving 2,224 coconut palms has been undertaken using one pint of 0.25 per cent dieldrin wettable powder suspension per palm. Full results of this trial are not yet available.

A breeding technique for the large-scale rearing of the endemic egg parasite *Ooencyrtus* sp. was evolved. A trial in which a particularly isolated block of 100 palms was saturated with *Ooencyrtus* sp. over a period of three months by fortnightly liberations of laboratory-reared stock, involving the release of 3,300 adult parasites, resulted in no appreciable reduction in *Pseudotheraptus* populations. An unidentified Encyrtid egg parasite was imported from Zanzibar and has been released at Gazi. A study is being made of the effectiveness of mass releases of this parasite in reducing *Pseudotheraptus* populations.

The assessment trial commenced in 1957 has continued throughout the year. Protected palms continued to yield at a higher rate than unprotected palms up to July, after which date the position was reversed. It is now clear that yield increase resulting from *Pseudotheraptus* control is not maintained at the high level experienced in the first year.

A study of flower production and yield of coconuts in relation to rainfall cultural conditions and *Pseudotheraptus* attack has produced interesting results. It has been shown that there is a highly significant positive correlation between female flower production and yield. Female flower production varies enormously from palm to palm under similar ecological and cultural conditions, and this variation is clearly genetic. There is also a seasonal variation which has been shown to be correlated with the amount of rain falling during the period seven to nine months prior to the opening of the inflorescence. The correlation between rainfall and yield has been shown to vary (under similar ecological conditions) with cultural practices. Yields from experimental plots in which

all weed competition is eliminated by regular hand weeding are 60 per cent higher than from plots cultivated in the standard estate manner by discing between rows in one direction only at three-monthly intervals.

The effect of *Pseudotheraptus* control on flower production and yield has been largely obscured by rainfall and genetic variation, neither of which can be controlled, and it will not be possible to arrive at detailed conclusions until the trial has progressed for a further year or two. In the meantime marked crop improvement can be achieved by regular cultivation to remove excessive soil moisture competition from weed growth, and further improvement would (in time) result from the institution of a well-planned seed-nut selection programme.

Cotton Pests

In an assessment trial at Msabaha crop value was increased by Sh. 173 per acre (75 per cent) by controlling all insect pests by regular spraying from flowering to first picking. Counts made throughout the season revealed that the main pest losses this year resulted from *Heliothis* bollworm attack, although spiny bollworm was also prevalent. Pink bollworm populations remained low, reflecting the efficiency of the closed season in the Malindi area. Stainers occurred particularly early this season, but then virtually disappeared until late in the season by which time much of the early planted cotton was past the susceptible stage.

In a comparison of D.D.T./W.C.1 with 3:10:0 (3 per cent gamma B.H.C./10 per cent D.D.T.) cotton dust, no significant yield or quality difference showed up. Neither dust gave satisfactory red spider control. 72 lb. of 3:10:0 dust per acre in six applications at seven-day intervals gave higher yields and better quality than 48 in four applications at ten-day intervals, and the economic return on the dust was higher, but not significantly so.

In a dusting trial carried out on eight peasant small-holdings, 72 lb. of 3:10:0 dust in six-weekly applications gave higher yields on every small-holding but one, but in many cases the outlay on dust was not fully recouped. This was not unexpected for late season rain not only interfered with dusting, but also led to a late season crop which largely compensated for earlier pest losses.

Maize Stem Borer (*Chilo zonellus*)

In a trial at Galole on maize three full-cover sprays of D.D.T. emulsion at 10-day intervals, commencing 11 days after germination gave better control than three sprays at 14-day intervals or two sprays only at 10 to 14-day intervals.

Mango Pests

Trunk banding with dieldrin proved ineffective in controlling ants attending coccids of mango, the principal ant species involved being the tree-nesting *Oecophylla longinoda*. A spraying trial was laid down in conjunction with the pathological section to elucidate the importance of pests and diseases to mango crop. Results are not yet available.

Entomological Investigations—Rift Valley Province

Mr. Bullock and Mr. Bond report as follows from Rift Valley Province:—

The principal insects covered by experimental work this year (1959) were barley fly (*Hylemyia arambourgi*) and pyrethrum thrips (*Thrips tabaci*, *Thrips* sp.). In addition, a new method of control was tested on army worm (*Laphygma exempta*). Scheduled experiments on stalk borer (*Busseola fusca*) and cutworm (*Euxoa* spp.) were not performed due to lack of suitable infestations.

Barley Fly

In a seed dressing trial comparing yB.H.C. (a persistent formulation) dieldrin, heptachlor, Rogor, Sevin and thiometon, only dieldrin and heptachlor gave good control. In further trials, dieldrin at a rate of 5 oz. a.i. per 100 lb. seed gave slightly better control than aldrin (4.8 oz. a.i.), but this difference was not as well defined as in 1958. Dieldrin seed dressings at rates of 2 oz., 3.5 oz. and 5 oz. a.i. per 100 lb. seed were tested in two experiments, and 3.5 oz. was found to be as good as 5 oz. Work is continuing on this aspect and it is probable that the recommended dose of 5 oz. a.i. can be reduced in the near future.

Post-emergent sprays applied eight days after planting were tested in two experiments, the compounds tested being dieldrin (two rates), heptachlor (two rates), D.D.T., chlordane, chlorthion, ekatin, guthion, metasystox and Rogor. In no case did these sprays affect the infestation of barley fly, as no attack occurred until three to four weeks after planting. It is evident that this cannot be regarded as a practical control measure, since it is impossible for a farmer to time the application.

The effect of a treatment on barley fly infestations on adjacent plots was tested by surrounding plots of untreated seed with (i) dieldrin-dressed seed, (ii) dieldrin-sprayed plants, (iii) untreated plants. Although the border plantings showed the expected differences (the dieldrin spray having had some effect in this case), the untreated centres were heavily and equally infested.

Tests on the effect of plant density showed that the percentage attack may tend to increase slightly with an increase of plant density, but that for practical purposes *percentage* attack may be regarded as density-independent in the early stages of growth.

Pyrethrum Thrips

A critical examination of the method of collecting samples showed that past inaccuracies in estimating thrips infestations in experimental plots could be overcome by sampling 50 marked plants, taking one leaf from each plant and repeating five times. The figures thus obtained gave a coefficient of variance of less than 15 per cent in a long series of tests. Using this technique reproducible results could be obtained provided that no change in the degree of infestation occurred during the experimental period. Numbers present on the plants were not affected by time of day or by minor meteorological changes, although a heavy rain storm would temporarily reduce numbers. Distribution on the plant was variable, sometimes greater concentrations occurring in the upper leaves; sometimes on the lower. No certain method could be devised to overcome this, but in practice it was found that collection was made from the part with the greatest leaf density, and this was unlikely to change during an experimental period.

The experimental method was changed from the use of statistical designs to single observation plots with interspersed controls. This was done because of insufficient labour to collect and examine samples from more than a few plots and because of the tendency of thrips to disappear from an experimental area completely, it being judged that a large number of small trials scattered in time and place were more likely to give results than a few large trials.

Chemical methods have continued to give satisfactory control. D.D.T. at a rate of 15 to 16 fluid ounces per acre as a medium-volume spray with two applications has continued to give satisfactory results, although the likelihood of infestations of the acarine *Tetranychus ludeni* is materially increased. The use of metasystox at a rate of 5 fluid ounces has been found to be successful

against both thrips and mites and in some cases one spray of metasystox has successfully controlled thrips. The single spray is not yet recommended since it has not been tested under all conditions. Of other insecticides tested, parathion at a rate of 12.8 oz. a.i. per acre gave very good results, but is not recommended because of toxicity hazards. Rogor at a rate of 4 oz. a.i. was variable in action, whilst chlordane, chlorthion, Dipterex, gamma B.H.C., guthion, Phosphamidon and pyrethrum were less satisfactory.

Cutting back pyrethrum has been advocated by some growers, but this was not found to be satisfactory, unless sprays were used as well, when penetration was enhanced by decreased foliage.

Recent microclimatic studies suggest a correlation between soil conditions and thrips infestation, and if this is so, it is possible that a cultural control may be possible.

Methods of applying insecticides have been examined, both by using fluorescent tracers and by thrips counts. The best penetration and cover was obtained with a manual knapsack sprayer, whilst on large acreages a normal medium-volume boom sprayer was satisfactory. The use of dusts has not been advocated through lack of satisfactory means of application. Application through a coarse-woven sack was not satisfactory, except on small plants, as a very uneven deposit was obtained. A power knapsack sprayer was found to be successful on small plants, but on larger plants the spray band was too narrow to cover the outer edges whilst the blast flattened the foliage and shaded the side furthest from the emission point.

Army Worm

Trials with the Land-Rover exhaust sprayer developed by Locust Control suggest that this ultra-low-volume sprayer may be used in the control of army worm on rough grazing. Six trials were conducted of which three were successful (a 78-80 per cent reduction being obtained), two were successful but were affected by other factors, pupation and polyhedrosis respectively, and one was unsuccessful due to lack of wind and too heavy a grass cover, which diluted the spray. Although further research is necessary, the present indications are that this method will be of great value in protecting sufficient grazing for maintenance of ranch and semi-ranch beef stock and for dairy herds.

Chafer (*Schyzonycha* sp.)

Maize in the Endebess area was damaged by chafer larvae. Spot treatments of various insecticides failed to give control.

Entomological Investigations—Nyanza Province

Mr. A. Davidson reports as follows from Nyanza Province:—

Cotton Pests

When all results are available they will be published fully in the Empire Cotton Growing Corporation Progress Report.

A period of drought from mid-May to late July, most intense in the lake shore areas, caused a severe set-back to early planted cotton, and a general reduction in pest populations. In spite of this, results from experiments in April-planted peasant plots in South Nyanza showed that 3 per cent gamma B.H.C., 10 per cent D.D.T. dust at 80 and 60 lb./acre (in five applications at ten-day intervals) gave yields of 1,341 lb./acre (20 per cent stained) and 1,198 lb./acre (20 per cent stained) respectively while untreated controls gave 1,026 lb./acre (33 per cent stained). Increases were economic in seven out of the ten plots for each treatment. In experiments on peasant plots in

Elgon Nyanza, sprays of 4 lb. D.D.T./acre (in four applications of eight gallons at ten-day intervals) gave good control of mirids and spiny bollworm (*Earias* spp.), with corresponding increases in green boll production, but yield figures are not yet available.

In a field experiment at Kibos, standard cotton dust (3 per cent gamma B.H.C., 10 per cent D.D.T.) was found to be superior to endrin/malathion/D.D.T. formulations both in kills of stainers (*Dysdercus* spp.) and in initial yields of seed cotton, although later pickings tended to equalize the effects.

A trial at Busia of two rates of application of D.D.T. (four applications of 1 lb./acre at ten-day intervals and six applications of ½ lb. at seven-day intervals) and two protection periods (mid-July to mid-August, early August to early September) on April-planted cotton gave slightly higher yields for the second application rate, and significantly higher yields for the later spray period, which corresponded to peaks in the populations of mirids and spiny bollworm.

The distribution and abundance of wild Malvales were recorded throughout the Province, 11 species were recorded as definite breeding hosts of stainers (*Dysdercus* spp., usually *D. nigrofasciatus*). These were *Abutilon asiaticum, A. mauritianum, Hibiscus cannabinus, H. panduriformis, H. aponeurus, H. vitifolius, H. fuscus, H. calyphyllus, H. flavifolius, Dombeya burgessiae, Ceiba pentandra.* None of these was found to support a large population of stainers at any time.

Stainers were also found feeding and breeding on a sorghum variety collection at Kibos. Examinations of all varieties showed adults feeding on 25 per cent of the red-grained varieties, and on 15 per cent of the white- or brown-grained varieties. Breeding occurred on one red-grained variety, and is reported by farmers and agricultural officers to occur on red varieties in South and Central Nyanza.

Studies of the movements of stainer populations were carried out in a checkerboard design with alternate plots of cotton and another crop (sorghum followed by beans). Marking experiments showed no tendency for the population to circulate between separate plots. Marking-recapture techniques were found to give less consistent estimates of stainer populations than random counts.

Coffee Root Scale (*Saissetia coffeae*)

Investigation of the bottling stem-pitting disease of coffee seedlings in nurseries at Kisii suggested that this scale might be either the cause or a vector of a pathogen causing the symptoms. Survey of all the nurseries showed no close correlation between occurrence of the scale and the symptoms. The scales were found to be very resistant to insecticides, young crawlers surviving in the protection of the maternal scale for up to three weeks. Dipping infested roots for five minutes in 5 per cent white oil or 2½ per cent white oil with 0.1 per cent Rogor was found to give complete disinfestation, and will be used in 1960. A survey of trees issued in previous seasons from the two most heavily infested nurseries showed a low incidence of scale, and most farmers agree that scale tends to disappear on transplanting from nurseries. The effect of treating new seedling beds with dieldrin to prevent infestation cannot yet be assessed.

Banana Weevil (*Cosmopolites sordidus*)

In a trial at Busia on the effects on yield of mulching and of spraying dieldrin, mulched plots, whether sprayed or not, gave three times the number of bunches given by sprayed, unmulched plots, which in turn gave twice the

number of bunches given by unsprayed, unmulched plots. Bunches from the mulched plots contained twice the number of fruit in those from the unmulched plots.

Army Worm (*Laphygma exempta*)

A severe outbreak of army worm occurred throughout the Province in late February and early March causing damage to young maize, sugar cane and grazing. Minor second attacks occurred in two areas in early April. Effective control was obtained by spraying 1 lb. D.D.T. per acre in European areas and dusting with 5 per cent D.D.T. in African areas.

Sweet Potato Weevils (*Cylas* spp.)

A species of *Cylas* believed to be *C. formicarius* was recorded at Busia and other places near the Uganda border, where it seems to do more damage, especially to stored tubers, than *C. puncticollis*. In a variety trial at Busia one local variety and two from lake shore areas were found to give high yields and will be further tested for resistance to weevil attack.

Biological Control of Insects

A further importation of *Eretmocerus serius*, a parasite of the citrus black fly (*Aleurocanthus woglumi*) was made from the Seychelles following confirmation that an earlier liberation had died out. 267 adults were liberated at Matuga and the parasite is now firmly established.

Biological Control of Weeds

Dactylopius tomentosus was established on prickly pear of three types at the Scott Agricultural Laboratories which originated from Mariakani, Naivasha and Laikipia. The former type, which also occurs at Karungu and is believed to be *Opuntia dilleni*, is severely damaged by the cochineal insect and plants may be completely destroyed. On the Naivasha and Laikipia types of pear the effects are less marked but nonetheless the insect has a definite restricting effect. Both at the Laboratories, at Naivasha and at Karungu no great rate of natural spread occurred and infested bracts must be moved to spread the species. There is thus little risk of the cochineal spreading to where it is not wanted. On the other hand, farmers wishing to spread the species must take active steps to do so.

The Lantana seed fly (*Agromyza lantanae*) now appears to be Colony-wide in distribution and must be a considerable factor in preventing spread by seeds.

At the coast the lace-bug (*Teleonemia scrupulosa*) is having some effect on the vegetative spread of Lantana. Up-country it seems to be less effective and at Kibos the small colony can no longer be found. A small but thriving colony is maintaining itself at the Scott Agricultural Laboratories.

A leaf skeletonizer (*Syngamia haemorrhoidalis*) was introduced from Hawaii, but it is not yet known whether it has established itself. Consignments of the Carabid beetle (*Tefflus* spp.) were sent to Hawaii in exchange. These are predators of the giant African snail. A consignment of the predatory snail (*Gonaxis quadrilateralis*) was also sent to the Seychelles.

Systematic Study of Coccidae

Mr. G. De Lotto, Entomologist (Coccid Taxonomy), reports as follows:—

The survey of the green scales of coffee in Kenya, Tanganyika and Uganda was completed. The material collected in various areas of East Africa together with specimens from other localities of Africa south of the Sahara

received from the British Museum (Natural History), London, was critically examined, and four new species, which in the past were confused with the common *Coccus africanus* have been discovered.

The monograph on the genus *Ceroplastes* from Africa has been continued further.

The study of a large collection of mealybugs from Africa has been completed, and many new species have been classified. A paper containing descriptions of a first group of 30 new species has been sent to the press.

Routine work on identification of Coccids from various parts of Africa was carried out throughout the year.

Publications

Bullock, J. A.—

"A Simple Method of Sampling for Pyrethrum Thrips", Pyrethrum Board, February, 1959.

"Chemical Control of Barley Fly", *Kenya Farmer,* March, 1959.

"Running Experiments and their Statistical Analyses" (Booklet on Experimental Procedure, pp. 79 + XV), Agricultural Department, Rift Valley Province, July, 1959.

Bullock, J. A., and Bond, D. C.—

"Points in the Control of Pyrethrum Thrips", Pyrethrum Board, October, 1959.

Bullock, J. A., with Graham, J. F., and Peers, A. W.—

"Seed Dressing Against the Black Wheat Beetle (*Heteronychus* spp.) in Kenya", *E. Afr. agric. J.,* XXV (I), pp. 23-24, July, 1959.

De Lotto, G.—

"Further Notes on the Ethiopian Species of the Genus Coccus (*Homoptera*: *Coccoidea*: *Coccidae*)", *J. Ent. Soc., S. Afr., 22*: 150-173.

"Two New Margarodidae (*Homopt.*: *Coccoidea*) from Kenya", *J. Ent. Soc., S. Afr., 22*: 385-389.

Brown, S. W., and De Lotto, G.—

"Cytology and Sex Ratios of an African Species of Armoured Scale Insect", *Amer. Naturalist, 93,* No. 873.

Graham, W. M.—

"Fumigation of Maize in a Large Shell Concrete Building", *J. Sci. Food Agric.,* 1959, *10* (9), 478-483.

"Temperature Preference Determinations Using Tribolium", *Animal Behaviour,* Vol. VI, (304), 231-237.

Graham, J. F.—

"Notes on Kenya Agriculture, VII: Insect Pests and Control Measures", *E. Afri. agric. J.,* XXV (I), pp. 2-9.

Various advisory leaflets were also produced.

Acknowledgements

The help of the Commonwealth Institute of Entomology in the identification of insects is acknowledged with thanks.

J. F. GRAHAM,
Acting Senior Entomologist.

ANNUAL REPORT OF THE SENIOR PLANT PATHOLOGIST, 1959

The emphasis of the work was changed towards the end of the year. A review of plant pathological problems in relation to the agricultural economy of the Colony made it possible to list plant diseases in order of importance. A short list of those diseases of major severity, confined to crops of which more than 30,000 acres are being grown, was compiled, and from this list it was possible to separate those diseases which showed promise of early control when control measures were applied. These diseases now form the substance of the programme of work. Outstanding amongst problems demanding immediate attention were seed-borne diseases of the major crops, especially of cereals and legumes. The survey showed that major economic gains could result from the general application of correct seed-dressing routines. Consequently, a new project was raised to begin a field investigation of the effect of fungicidal seed dressings.

Meanwhile, it was also evident that work on legume bacteriology had either to be increased in tempo or discontinued altogether. There was a falling market for legume inoculant supplied by the section, and it was not apparent whether the inoculation of seeds was either necessary or beneficial in any area of the Colony. The work was consequently raised to full project status in order to determine whether there was a place for legume inoculation in the agricultural economy.

This has meant that apart from the potato work and the Government seed-testing laboratory, which continue unchanged, little time remains for routine advisory work, which has consequently suffered from lack of attention. The efficiency of the advisory service and the speed and quality of advice coming from it are seriously impaired.

Seed-borne Diseases

Barley.—In 1958 there was a severe outbreak of leaf scald (*Rhynchosporium secalis*) which assumed epidemic proportions in many places where barley is grown in Kenya: affected crops were seriously damaged and yield was considerably reduced; grain from affected plants was small and of poor quality.

Equally common on Kenya barley are two other leaf diseases, *Cochliobolus sativus* (seedling blight) and *Pyrenophora teres* (net blotch).

Three replicated rod row trials were carried out during 1959 at Njoro, Nairobi and Naro Moru.

Full control of the seed-borne phase of all three diseases has been achieved by the application of organo-mercurial seed dressings at an adequate dosage level of mercury on the seed. In the resultant plants the lower foliage remains clear of scald during the tillering stage and is free from net blotch and seedling blight. Plants from untreated seeds are diseased and coming into ear is delayed by several days, by comparison with healthy plants.

The prevention of attacks of barley bulb fly on the young seedlings has been shown to be of parallel importance. In the trial at Njoro in which the effect of 18 seed dressings was being compared, seed dressings which did not have an insecticidal component had no effect in preventing severe barley bulb fly attack and the plants were almost entirely destroyed, whereas the adequately protected plants which received insecticidal dressings were unaffected. At the other trial sites at Scott Laboratories and at Naro Moru, although insect damage was scarcely discernible, seed dressing with both an insecticidal and a fungicidal component resulted in consistently higher yields than dressing with only an insecticidal or a fungicidal component.

Five commercially available seed dressings gave adequate protection against seed-borne diseases and insects in all three trials. Recommendations for the application of these, drawn up jointly with the Senior Entomologist, are as follows:—

(1) *Dieldrin/organo-mercury*—

(*a*) Dieldrex M. (Shell Chem. Co.), 10 oz./100 lb. seed.

(*b*) Agrosan D. (A.E. & C.I. Ltd.), 10 oz./100 lb. seed.

(*c*) Murseedress 2 (Murphy Chemicals), 8 oz./100 lb. seed.

(2) *Aldrin/organo-mercury*—

(*a*) Merdrin (A.E. & C.I. Ltd.), 12 oz./100 lb. seed.

(*b*) Aldrex M. (Shell Chemical Co.), 12 oz./100 lb. seed.

Net blotch and seedling blight are apparently well controlled by seed dressing, but although scald can be prevented on the young plants there is some doubt about epidemic outbreaks of scald occurring from air-borne spores. Outbreaks could occur on the upper foliage, particularly if there were volunteer plants from a previous crop in the field or if there were crops in adjacent fields grown from untreated seed Seed dressing will fail to prevent such outbreaks and the best hope of prevention of future epidemics seems to lie with the universal adoption of correct seed-dressing routines and the suppression of volunteer plants arising from residues of the previous crop.

The trials are still in progress and when full yield figures have been collected detailed results will be published.

Pyrethrum.—The effect of seed dressings on germination was investigated. Germination of pyrethrum seed is very poor and was not improved by any of the seed dressings tried. There was, however, a marked reduction in damping-off resulting from attacks of *Rhizoctonia,* with some treatments.

RESULTS (means of four replicates)

Seed-dressing Treatment	Seedlings Surviving per 100 Emerged
Harvesan (organo-mercurial) ..	30
Captan	78
Spergon	62
Fernasan A (thiram)	64
Actidione	16
Perenox (cuprous-oxide)	56
Nil	26

Rhodes Grass.—The effect of organo-mercurial seed dressings in controlling seed-borne *Helminthosporium* is under investigation.

Beet.—Treatment with captan and thiram seed dressings gave improved stands of beet. Organo-mercurial dressings had no effect on stands as compared with untreated seed.

Passion Fruit

Seed of *Passiflora edulis XP. edulis var. flavicarpa* crosses and back-cross was obtained from the Department of Agriculture and Stock, Brisbane, Australia, and is gratefully acknowledged. This seed is now being grown for testing with the Kenya strains of woodiness virus.

Bacterial Wilt of Potatoes (Pseudomonas Solanacearum)

This disease is now causing considerable anxiety. The disease can be very damaging; losses of 50-70 per cent are common and losses of 100 per cent are not unknown. Spread of the disease within Kenya occurs with the normal sale and movement of potato seed tubers which can appear quite healthy but still carry the disease. The bacteria appear to be able to survive in the soil indefinitely and the amount of contaminated land in Kenya is increasing. There is no known economic control for the disease, apart from preventing the planting of diseased tubers.

Bacterial wilt was the subject of a special disease survey during 1959. The assistance of many Field Division Officers is gratefully acknowledged. From this survey it appears that there are now some thousands of distinct outbreaks of the disease, mainly in Central Province. Estimates of loss varied from "one plant only" to "whole crop destroyed". The average loss in crops where the disease occurred was 20 per cent. Other types of data, such as the effect of altitude, potato variety, rate of spread, rainfall, soil type, etc., were also obtained and will form the subject of a separate report.

Bacterial wilt also attacks tomatoes in Kenya, but the strains which attack tobacco, bananas, groundnuts, castor, chillies, etc., have not been recorded. It might be inferred from this that the disease is an introduced exotic. If it is indigenous, however, recent increases in the amount of bacterial wilt are not due solely to the spread of diseased seed, and any scheme to prevent further spread of the disease by the use of disease-free seed might fail.

Agriculturally, bacterial wilt poses three problems according to the type of farming systems involved. In the Agricultural Department areas of Central Province, there are many thousands of small African-owned farms with small crops and only limited possibilities of rotation. It is these farms which are most likely to be spoiled for potato production. In the Forest Department areas there is a system of shifting cultivation based on the clearing of indigenous forest by resident labourers, who then sow young plantation forest trees and cultivate the land for their own benefit for four years before moving to another forest area. Provided that *Ps. solanacearum* is not indigenous in these soils and that disease-free seed tubers are used, bacterial wilt need never be a serious problem in these forest areas. Furthermore, such forest areas may constitute an invaluable source of disease-free seed tubers for the small, permanent farms of Central Province. In the European farming areas of Rift Valley Province, the disease is not widespread.

Advisory

Six hundred and thirty-eight specimens were examined during the year. Two hundred and forty-five were from members of the public and 393 were from the Department of Agriculture. Six new disease records were confirmed during the year, as follows:—

Septoria sp. on *Clitoria ternatea* I.M.I. 75999.

Entyloma australe on *Physalis peruviana* I.M.I. 75801.

Sphacelotheca ophiuri on *Rottboelia exalta* I.M.I. 75994.

Leveillula taurica on *Solanum melongena* I.M.I. 75995.

Alternaria spp. on *Glycine max* I.M.I. 75996.

Momordica charantia I.M.I. 75998.

Legume Bacteriology

One hundred and ninety-eight orders for legume inoculant were received during the year. These orders involved 1,038 units of inoculant as follows:—

UNITS OF INOCULANT SOLD

Inoculant Group	Outside Kenya	Public	Govt.	Total	Pounds of Seed for which sufficient
Lucerne	2	69	143	214	4,280
Kenya Clovers	7	90	112	209	4,180
Temperate Clovers ..	1	15	52	68	1,360
Lupin	0	179	58	237	9,480
Pea	0	31	1	32	1,280
Soya	2	5	45	52	2,080
Miscellaneous	24	61	141	226	6,780
Totals ..	36	450	552	1,038	29,460

The number of units prepared for Government Stations (principally those belonging to the Department of Agriculture) shows a slight increase over 1958, but public demand has decreased by nearly 200 units compared with last year. There was also a decrease of nearly 100 orders, attributable to the increased availability of commercially produced "dry" inoculants.

Little investigational work was possible during the year, and apart from the manufacture of inoculant, laboratory work was confined to the routine maintenance and testing of culture collection.

A *Rhizobium* "bank" has been constructed for the maintenance of strains in living nodules on growing plants. The bank has a capacity of 100 host legumes which are widely distributed over half an acre and separated by a dense turf of *Cynodon dactylon.*

An inoculant dosage rate trial was carried out at Galole using soya as the test legume. Treatments using (1) normal, (2) twice, (3) four times, (4) eight times and (5) 16 times the normal dosage were compared with uninoculated controls (the normal inoculant dosage rate for soya supplies between 3,000 and 4,000 living *Rhizobium* cells per seed).

All inoculated plots formed pink nodules, irrespective of dosage rates, while the uninoculated controls formed no nodules. However, control plots which had received nitrogenous fertilizer produced greener plants than the inoculated plots and it appears that the nodules had fixed little or no nitrogen in spite of the presence of haemoglobin.

Potato Development, 1959

Six tuber samples of the following seedlings were received from Dr. William Black of the Scottish Society for Research in Plant Breeding:—

1521 c (3).
2288 a (2).
2299 (10).
2320 b (2).
2403 c d (4).
2404 a (14).
2404 b (1).
2407 a (3).
Pentland Beauty.
Pentland Crown.

100 lb. each of "Ulster Malta", "Ulster Prince", "Ulster Chieftain" and "Stormont 480/51" were kindly supplied by the Ministry of Agriculture for Northern Ireland. 100 lb. of foundation seed of "Kerr's Pink" and 100 lb. of stock seed of "Up-to-Date" were kindly supplied by Sir T. A. Wedderspoon of Castleton of Eassie. 10 lb. of the variety "Sirtema" were kindly supplied by Dr. Hogen-Esch, from the I.V.R.O. Institute of the Netherlands. 7 lb. samples of "Royal Kidney", "Duke of York", "Dr. Vernon", "Dr. McIntosh", "Golden Wonder", "Home Guard" and "May Queen" were obtained from the United Kingdom. Ten tubers each of the Mexican varieties "Conchita" and "Elenita" were kindly supplied by Dr. Niederhauser of the Rockefeller Foundation, Mexico, to augment the collection previously supplied. A sample of "Jersey Royal" was kindly supplied by the Director of the Jersey States Experimental Station.

A five-day "recognition course" for departmental officers engaged in crop certification, to which the public was invited, was organized in May in connection with the multiplication and demonstration plot of some 90 varieties at the Scott Laboratories. Among the varieties demonstrated were blight resisters from the Scottish Society for Research in Plant Breeding, standard United Kingdom varieties, some of the latest from Ulster bred by John Clarke, a collection of Dutch potatoes from the Netherlands and blight resistant potatoes from Mexico. During the course, talks were given on the botanical characters on which differences in character are based and on aspects of blight and blight resistance. Two visiting experts gave talks on marketing, market trends and requirements.

A similar but smaller plot was demonstrated later in the year to members of the Royal Agricultural Society of Kenya.

Government Seed-Testing Laboratory

The number of samples received for testing was 2,699, consisting chiefly of cereals, vegetables, flowers and grasses.

Certificates for Government-certified seed and Government-tested seed were issued for the first time this year.

Hop seed was tested for the first time. Five samples of seed, about nine months old, were received from America. Two samples gave better germination than the others.

Experiments were done on various vegetable and crop seeds for an insurance firm. The seed had been subjected to heat and it was necessary to know whether the estimated heat, 150 deg. F. for one hour, would spoil germination. No deterioration had occurred in the heated seed, when compared with the controls.

Packet seed bought at random from shops in Coast Province was tested, and in nearly every case germination was found to be poor.

Of interest amongst grass seeds has been the improved germination shown by Panicum and Setaria seed, and Cenchrus seed from Machakos Experimental Station. Rompha grass, a hybrid (*Phalaris tuberosa X P. arundinaceae*), was found to be sterile.

Passiflora seed from Australia was found to germinate well without further treatment. Turkish tobacco seed was also tested for germination and gave good results.

Nyanza and Central Province Marketing Board sent in samples of beans, sunflower, castor and grams for identification of varieties.

The Chief Grader and Inspector submitted seed under Indian names for identification.

Members of the public and of the Department sent in various plants for identification, some of which the East African Herbarium very kindly named. Seventy-five plant specimens were pressed and added to the Herbarium.

Visitors to the Seed Laboratory included Mr. Wilbur H. Youngman of the United States Department of Agriculture, Ir. Hogen-Esch, Holland, Dr. Taylor, Director, Kew, the Principal and students of Egerton College, and the Plant Pathologists from Tanganyika Department of Agriculture.

E. HAINSWORTH,
Senior Plant Pathologist.

ANNUAL REPORT OF THE SENIOR SOIL CHEMIST, 1959

Soil Survey

(Dr. J. Thorp, Mr. G. A. Woodruff, Mr. F. T. Miller, Mr. F. W. Collier)

Soil surveys continued to benefit from the presence through a good part of the year of Dr. Thorp and Mr. Miller and from the continued service until the end of the year by Mr. Woodruff of the I.C.A. team. The return of Dr. Thorp and Mr. Miller to America in August at the end of their tour was keenly felt.

Dr. Thorp concentrated mainly on the continuation of his study of Kenya soils with a view to the publication of an account of them and to the development of a framework for their classification. He returned to America heavily laden with the profile descriptions, analytical data and maps needed for the compilation of his report. This is now awaited.

The report on the Songhor survey, the field work of which was undertaken in 1958, was completed and edited. This is now with the Government Printer for publication. The accompanying maps are in Great Britain with the Directorate of Overseas Survey. Cartographic details on them have been agreed and the Directorate is now preparing them for printing. A field party completed the East Konyango survey and the report on it has been written up. This is now being edited drastically in preparation for publication. The accompanying maps have been drawn and these have now been revised and forwarded to the Directorate of Overseas Surveys for preparing for printing. The East Konyango survey completed, the party moved to Nakuru to initiate a similar soil survey of the Solai area. This survey is being continued by Mr. Collier, Soil Surveyor, Kenya, alone, now that his American instructors have left. The survey and report compilation procedures followed in the East Konyango and Solai surveys are as described in the 1958 Annual Report.

Additionally, some 20,000 acres of general farmland were surveyed around Sotik and an area near Michimukuru, Meru, was surveyed for its suitability for tea. A number of areas in the northern Uaso Nyiro catchment were reconnoitered and assessed for their irrigation potential in connexion with a hydrology study initiated with I.C.A. assistance by the Water Resources Authority with the object of developing a comprehensive plan for the utilization of the waters of the catchment. Reports on these minor surveys have been circulated to the interested parties or are under preparation. As a result of the Michimukuru survey the Administration has now set aside 630 acres of the area for a commercial tea project.

The area covered by the East Konyango survey was found to form part of the basin of the Kuja River. Here, a broad undulating plain over granite or mixed alluvium or volcanic ash and made up of a series of low, nearly level ridges dipping gently into wide, flat, shallow valleys draining in a generally south-westerly direction, made up the main part of the basin. This monotonous plain is broken to the north-west by a series of lava flows and ash deposits which rise gently to the water-shed to the north and west. More prominent features in the landscape are hills of Rhyolite and granite which stand 100 to 200 ft. high on the north-eastern, eastern and south-western fringes of the survey area. The Kuja River and its main tributaries have cut fairly deeply into the plain in the south and south-west, the lowest land in the survey area being in the Kuja River south of Migori at an elevation of about 4,100 ft. above sea level. The highest land is on the hills near Rangwe, in the north-east, the elevation here being quoted as 4,687 ft. The rising land formed in the western part of the survey area by the volcanic formations breaks abruptly on the water-shed forming the western boundary of the survey area, to the magnificent Kaniamwia Escarpment, in places some 1,500 ft. high, which drops sheerly to the west into the Lambwe Valley.

Within the plain which forms the core of the survey area, drainage relations are poor and most soils have the sandy loam topsoil and sharp break to the heavy textured subsoil which is characteristic of the Planosols (plains soils). Stream terraces and flood plains are limited to small areas near the streams and are discontinuous. More typically the bordering hills are flanked by long gentle fanlike slopes. These slopes receive seepage water from the neighbouring higher land and many become swampy during rainy periods. In these situations the subsoils tend to bear the quite intense mottling which is characteristic of Low Humic Gleis (wet meadowland). Where seepage is particularly intense, narrow bands of soil with actively developing Groundwater Laterite (murram) can be found. A high exchange sodium status giving rise to Solonetzic (alkali) soils frequently is encountered in the bottoms of the broad flat valleys: this arises from seepage into the area from the surrounding soda-rich rocks and soils, associated with imperfect drainage which prevents the free escape of this water from the soil and leads to the concentration of its contained ions by evaporation. These Solonetzic soils are highly susceptible to gully erosion. Where such erosion has occurred the exposed subsoil is highly saline and is extensively used by local stock owners as salt licks. Utilization of these situations as salt lick further accentuates the gullying and the situation is now sufficiently widespread for it to be mapped as a distinct soil unit.

In areas where lavas and ash have made major contributions to the soil parent material and possibly led to some improvement at least in surface drainage, the soil tends to lose the sharp textural change from topsoil to subsoil of the Planosol and to acquire the uniform heaviness and blackness which is characteristic of a Grumusol (black cotton soil).

On the hills and steeper slopes fringing the basin, well-drained but distinctly shallow soils are found overlying ancient (pre-Miocene) Rhyolites and granites and more recent lavas. In these shallow soils, typically the rock is capped with hard Laterite (murram) and the soil as a whole contains much murram gravel. The Laterite is regarded as Groundwater Laterite formed in past ages when drainage conditions in these soils were distinctly less free than those now prevailing. Conceivably the Laterite could have been formed as a result of footslope seepage, similar to that now taking place on the edge of the undulating plain, during the course of the gradual wearing down of that plain to its present level.

Laboratory and greenhouse examination of the East Konyango soils disclosed widespread phosphorus and nitrogen deficiencies and some need for sulphur. In a number of instances, indications of low available Boron and low subsoil potash also were observed. Other nutrient deficiency indications were of only sporadic occurrence. The soils were found to fall into three distinct groups on the basis of their dilute acid extractable phosphorus content. In this they resembled the soils of the Songhor survey area.

Where the phosphorus content was low to medium in the surface, low in the subsoil and medium to high at depth, the soils were those which the field surveyors regarded as "suitable" or "usable" for sugar cane production provided that the soil depth was adequate. These soils generally have some need for phosphorus and sulphur and a great need for nitrogen. The group includes the more extreme Solonetzic soils of the area. On these, high dilute acid extractable sodium levels were recorded and growth characteristics associated with high salinity and sodium availability have been observed both on tomatoes in the greenhouse (an unusual dark greenness of foliage) and on sugar cane in the field (a high salt content in the juice ultimately impairing the acceptability of the crude sugar obtained from it).

The suitability for sugar cane of some of the soils with a low surface phosphorus but a high to medium subsoil phosphorus is limited either by excessive

wetness and shallowness or extreme acidity and density of natural bush cover. As at Sognhor, all the soils with medium to high phosphorus in the subsoil are derived from basic parent materials (volcanic tuff, ash and basalt).

Of the soils with a low phosphorus content through out the profile all but one are derived from acid rock parent material (Rhyolite or granite) and all those with adequate depth are considered by the field surveyors to be "usable" for sugar. On account of the relative ease with which they can be cultivated the more friable Groundwater Laterite soils, though too shallow for satisfactory sugar cane production and too shallow to have a good water holding capacity, are strongly favoured by local peasant cultivators for subsistence crop production. These soils wherever they occur are intensely and continuously farmed for simsim, cowpeas, finger millet, cassava, sweet potatoes and maize.

The soils so far surveyed at Solai are derived from a succession of violent erruptions of Mt. Menegai in Miocene, Pliocene and Recent geological times. These have given rise in freely drained situations to a distinctive range of reddish brown (on the more recent rocks) to red or yellowish red (on the most ancient rocks), loamy soils, the most recently formed of which are strongly banded with pumice gravel. Extensive earth movements associated with the volcanicity of the area and subsequent to the major Rift Valley faulting have given the land a complex surface and have imposed a drainage pattern which to a large extent determines the soil distribution on each of the rock formations. About 80,000 acres of the Solai area have been traversed.

On the lower Uaso Nyiro, some 180,000 acres below Kittermaster's Camp and the Merti Plateau which had been selected by the hydrologists investigating the water resources of the Uaso Nyiro catchment were reconnoitered. Of these, some 140,000 acres were considered to warrant detailed examination. Six soil associations were recognized on the basis of local physiography, the most widespread and important of which are a series of alluvial terraces and fans derived from or at present being laid down by the river or from sediments washed from the Merti Plateau. While the local landscape is virtually devoid of vegetation, this the field surveyors attribute to over-grazing under local desert conditions. They consider the soils adequately permeable for successful irrigation and for the leaching of excessive salinity where it occurs in sufficient land to exist with an adequately low exchangeable sodium content for successful irrigation to be possible. Over much of the area they consider flood protection or adequate protection from local storm-water to be necessary while a number of low sand dunes would need either negotiating or levelling.

In the upper Uaso Nyiro a number of areas selected by the hydrologists also have been inspected and the suitability of the soils there has been assessed on the basis of the experience of already established local irrigators. Six groups of soils were recognized. The lighter textured and better structured clay soils with calcareous subsoils extending to a depth of 4 to 8 ft. over tuff or lava were considered suitable for irrigation. Other soils were too heavy and intractable or too shallow, too stony or too steep for irrigation, while drainage of some of the swamps seen with a view to their irrigation was considered possible. Elsewhere, potenial irrigable land was found between bands and pockets of stony soil in sufficient amount to warrant further investigation. Laboratory data on samples collected during the course of the upper Uaso Nyiro survey agreed very satisfactorily with the field assessment of suitability. Differences in tillage characteristics were closely related with exchangeable sodium indications.

The Michimukuru survey area lies some 30 miles north-east of Meru on the western slopes of the Nyambeni hills at an elevation of 6,500 ft. and under a rainfall of about 55 to 60 in. The area is blanketed with dense bracken and small bush with rain forest on the higher slopes. The soils are moderately deep, well

drained, very friable and reddish brown with good water holding capacity, but occur on such precipitous slopes that great attention will need to be paid to erosion control. The soils are strongly acid to depth and have a low to extremely low available nutrient status, though this absence of nutrients appears not to be important for tea.

The surveys and Dr. Thorp's more general activities were used to provide further training for Mr. Collier in American methods of soil surveying.

The Sotik survey covered an area at between 6,000 ft. and 6,600 ft. elevation with a well distributed annual rainfall of 50 to 70 in. The soils here are derived from a variety of volcanic lavas and ashes, ironstones and granites, but parent material was found to have relatively little effect on soil characteristics. Instead, drainage was found to be the main soil determining factor. On hillsides and upland situations, the soils are deep, heavy, well drained, friable, reddish brown Latosols (red earths). In the valley bottoms and on flat shelves on the hillsides the soils develop the grey sandy loam surface with a sharp break to a heavy textured subsoil which is characteristic of Planosols. Both main groups of soils show minor variations in texture and chemical constitution attributable to their parent materials while the Latosols show sufficient unexplained variation in acidity for some of them to be suitable for tea growing in areas of adequate rainfall while others are not. The natural vegetation of the upland soils is stated to be Low Tree-High Grassland Savannah and of the Planosols to be a characteristic Grouped Tree-Grassland association.

Soil Test Methods

(Dr. A. Mehlich and Mr. R. J. Kempton)

The Chemistry Section continued to be stimulated by Dr. Mehlich's ideas right up to his departure for America in mid-July on completion of his tour. We look forward to his return for a further tour of duty under I.C.A. in 1961. Meanwhile, Mr. Kempton, on his return from America, understudied Dr. Mehlich and carried on the collection of analytical data on the basis of the Mehlich concepts. Additionally, a number of field fertilizer trials have been started mainly on sugar around Songhor, the treatments applied in these trials being determined by the laboratory indications of the Mehlich procedures on soils from their sites. The routine chemical assays have been speeded up through the introduction of a number of mechanical pipettes and by the replacement of the old potentiometric pH meter with a direct reading instrument. The purchase of these instruments was made possible by I.C.A. finance.

Investigation of the Barkoff (*Jour. Sci. Agric. Soc., Finland, 26* (1954) 198-210) organic determination method was continued and a suitable procedure for the bulk handling of samples was developed. Through the co-operation of Dr. Clement of the British Grassland Research Station, Hurley, Berkshire, England, it was possible to have a comparison made of the Scott Laboratory version of the Barkoff procedure with the rapid wet oxidation method used at Hurley and with the standard wet oxidation method of Shaw (*Jour. Soil Sci., 10* (1959) 316-326). The results obtained by the three methods were in excellent agreement.

The development of the Mehlich rapid test procedures was followed by his development of a first approximation interpretation framework on which tentative soil treatment recommendations for a wide variety of crops could be made with a view to the field verification of the laboratory findings. In developing this framework, some 65 common farm and garden crops were classified according to published data or local knowledge of their acidity tolerance, phosphate requirement and nitrogen consumption into "high", "medium" and "low" groups in

respect of each of these characteristics. The calculation of the amount of lime to be applied to acid soils to raise the pH sufficiently for growing less acid tolerant crops was based on the colour and texture of the soil, its pH (here used for estimating the intensity of its hydrogen saturation) and the chemical indications of its basic nutrient status (here used as an estimate of the base status corresponding with the degree of hydrogen saturation indicated by the pH determination). Where the lime requirement so found proves to be uneconomically large, band placement of the lime close to the crop, application of soluble calcium salts or the growing of more acid-tolerant crops is recommended. Potash application is recommended where the exchangeable potash content is less than 0.3 m.e. per cent or where the Ca:K ratio exceeds 12. Magnesium application is recommended where the exchangeable magnesium is less than 2 m.e. per cent and the Mg:K ratio exceeds 2. Where a low soil magnesium status is associated with foliar symptoms of magnesium deficiency, the supplementing of ground with foliar application is recommended. Generally high rather than low sodium levels are regarded with concern and where these are found, particularly in soils which are low in calcium, soil amendment application of Gypsum is recommended. Manganese is regarded as lacking only when soil pH exceeds 5.8 in association with an exchangeable manganese content below 0.2 m.e. per cent. A look-out for manganese toxicity is recommended when the soil pH is below 5.3 and is associated with an exchangeable manganese content above 1 m.e. per cent and low calcium and magnesium availabilities. Liming and phosphating are recommended where manganese toxicity is suspected. Phosphorus application is recommended at rates determined by the phosphorus requirement class of the crop and by the chemical and Cunninghamella indications of soil phosphorus status. A chemical value of 15 p.p.m. or less and a Cunninghamella value of 30 per cent or less are regarded as indicating a very low phosphorus status. Levels of 15 to 30 p.p.m. or 30 to 50 per cent indicate a medium status and levels in excess of 60 p.p.m. or 75 per cent very high phosphorus status. Nitrogen recommendations similarly are based on the crop rating for nitrogen consumption and the Cunninghamella test. A figure of less than 20 per cent in the Cunninghamella test is regarded as indicating a very low nitrogen status, a figure of between 20 and 50 per cent, a medium status and a figure of over 80 per cent a very high status.

The recommended form in which fertilizers aiming to adjust deficiencies in N, P, K, Ca and Mg are applied depends partly on the acidity of the soil in relation to the crops it is desired to grow on it and partly on the sulphur status of the soil. Where soils are acid, farmers are recommended to avoid acid-forming fertilizers. Where the tests indicate a low sulphur status, sulphur-carrying fertilizers are recommended in preference to non-sulphur-carrying fertilizers, particularly for legumes, tobacco and sugar cane (crops on which definite sulphur responses have been observed). Where no other deficiency than sulphur is indicated or where no convenient sulphur-carrying fertilizer is available, fertilizer applications of Gypsum are recommended. Sulphate forms of fertilizer are recommended no matter what the sulphur indications are for crops such as potatoes whose quality is known to benefit from sulphate fertilizers.

The examination of the results of the soil Mehlich tests during the first year and a half of their operation showed that over half of the Coast soils analysed were low in calcium, magnesium, potassium and/or manganese and over half of the soils from Meru, Fort Hall and Nyeri were low in calcium. Low magnesium was most common in Southern Province and on the Kinangop and low potassium in Nyeri. Extreme acidity was most common in Fort Hall and Nyeri. Low phosphorus status was widespread on the Coast in the southern part of Central Province and in Meru, Laikipia, Nakuru, Kitale and Kericho Districts. Low nitrogen availability was common in Nyeri, the Kinangop, Ktale and Kisii. Low

sulphur occurred throughout the Colony, but was not prevalent anywhere. Sulphur deficiencies are most conspicuous on Grumusols and Glei soils and on soils derived from Schist, Gneiss, Quartzite and Granite and on youthful volcanic soils derived from tuff. Unduly high and unduly low manganese figures were of only sporadic occurrence.

Clay characterization by the chemical measurement of charge distribution continued, but with this procedure as with aspects of the Mehlich nutrient assessment there has been a growing realization of the need for improvement or modification of technique. The clay characterization method is based on the determination of the cation exchange capacity of the soil both in its native condition and after its contained sesquioxide hydrates have acquired a cation exchange capacity as a result of phosphate treatment, and of its anion exchange capacity in its native condition. The amount whereby the cation exchange capacity of the phosphated soils exceeds that of the soil in its native condition is taken as a measure of the hydrated sesquioxide content. The hydrated sesquioxide constituents in the native condition are regarded as dominantly positively charged material. The anion exchange capacity of the soil is taken as measuring its total positive charge capacity. Accordingly, the amount by which the anion exchange capacity exceeds the charge capacity attributed to the sesquioxide hydrates is taken as a measure of the other potential positive charge contributing components of the soil. These are regarded as mainly the 1 : 1 lattice (kaolinitic) constituents. In the 1 : 1 lattice constituents, each active positive charge is counterbalanced by an active negative charge. Consequently, the 1 : 1 lattice constituents are regarded as contributing to the cation exchange capacity (which is taken as a measure of the total negative charge) of the native soil to the same extent as they contribute through their positive charges to the anion exchange capacity. The amount by which the cation exchange capacity of the native soil exceeds the capacity regarded as due to the 1 : 1 lattice-type constituents is taken as measuring the other negative charge contributing constituents of the soil. These are regarded as mainly the 2 : 1 lattice (Montmorillonitic) and humic constituents.

The validity of this theoretical background to the chemical characterization of clays has been strongly criticized, particularly with regard to Dr. Mehlich's simple anion exchange capacity concept and to the method he adopts for its measurement. Quite apart from theoretical considerations, the determinations suffer the disadvantage that the accuracy of each of the clay constituent determinations depends in large measure on the accuracy with which the others are determined. The result is that an error in the measurement of one of the capacity factors can give a totally erroneous clay constituent pattern indication. The analytical procedures are comparatively long and exacting and opportunities for error are considerable. When the X-ray diffractometry unit now with us is installed, a valuable clay constituent determination procedure for soils will be available on which it will be possible to judge the true value of the Mehlich procedures.

In like manner, accumulated experience has shown the Mehlich extraction of sodium to be very incomplete in soils which are rich in extractable sodium. Ammonium acetate leaching on soils with pronounced Solonetzic characteristics has given extractable sodium figures as much as three times the Mehlich sodium figures and has indicated sodium levels which are typical of Solonetzic soils, while the Mehlich sodiums have been tantalizingly low.

Even so, the value of the Mehlich procedures was forcibly demonstrated when three farms in the Nakuru District were sampled systematically and in detail for laboratory determination of the fertility status of their surface and subsurface soils. In preparing for sampling these farms, their relief was examined in detail and on this basis the physiographic units into which they could be subdivided

were isolated. Each physiographic unit was further subdivided on the basis of its present use, with particular reference to its current cropping and the period during which it had been under grass or cultivation. These units were further subdivided on the basis of the farmers' field assessment of the fertility of each part of the unit and where the units so obtained were still large they were further subdivided until the individual sampling units were less than ten acres each in extent. This final subdivision normally was made across the slope in recognition of the possible effect of seepage on the distribution of plant nutrients down a hillside. The sample ultimately submitted from each land unit thus obtained was a composite from numerous well-scattered points in the subunit. On two of the farms near Mount Menengai, the well-recognized low phosphorus status of the local soils was found to be aggravated by a general low nitrogen availability which one of the farmers himself had been beginning to realize on the basis of his field experience, and by a consistently somewhat low magnesium status which could become an important factor in the current expansion of coffee growing in the locality. The third farm is situated at Molo in much more hilly country and here the fertility variation over the farm was correspondingly great. A field examination of the laboratory data by the owner and the local Farm Planning Officer revealed close agreement between the laboratory test results and the farmer's assessment of the fertility of the various parts of his farm and of the effect of the practices he had adopted for its improvement.

Bioassay

(Mr. A. Pinkerton)

Cunninghamella determinations following the Mehlich procedure (Annual Report, Chemistry Section, Department of Agriculture, Kenya, 1958) now form part of the routine soil analyses. Accumulated experience has shown the organism to behave quite consistently in the determination of nitrogen, phosphorus and sulphur availability, but in spite of considerable investigation, reproducable results have not been obtained in its use for the determination of trace element status.

Pot tests mainly using tomatoes as indicator plants were continued throughout the year, in all, 49 soils being examined in the rather cramped space available. The purchase and erection of a new large aluminium-framed greenhouse and an extension of laboratory facilities for bioassay work in the chemistry laboratory extension which was made possible through a generous contribution of C.D. & W. funds led to a considerable relieving of pressure on existing facilities at the end of the year and opens up the prospect of an increased output and improved standard of work in 1960.

Of the 49 soils examined, 18 were in extension of the laboratory investigation of the more important soils found in the East Konyango soil survey. Thirteen were from Nakuru District in connexion with an investigation of the extent of the soil copper deficiency area in that district. Four were in extension of the laboratory investigation of the soils of the two Mount Menengai farms which had been sampled in detail. Seven were "black cotton soils" from the Athi Plains examined at the request of the Soil Conservation Service and seven were from other parts of Kenya at the request of field officers.

Nitrogen and phosphorus deficiencies were again widespread and severe. Sulphur deficiency was common in Nyanza and on poorly drained Planosols at Naro Moru and was indicated on all the Athi Plains "black cotton soils".

Six of the soil types from the East Konyango survey gave indications of Boron deficiency with the tomato, but in only one was there a statistically significant reduction in growth when the element was omitted (compared with the control treatment). As chemical analyses for water-soluble Boron (the carmine

method of Hatcher and Wilcox (*Analyt. Chem., 22,* 567-569, 1950) was found preferable to that using quinalizarin (A.O.A.C., Seventh Edition, 39)) did not correlate with the incidence of deficiency symptoms, attempts were made to assess the degree of severity of deficiency by growing crops of varying Boron requirement in the soils. Three soils that had given Boron indications previously from the Songhor survey area were tested along with those from East Konyango using beans, lettuce and cauliflower. The results were inconclusive, differences in growth between treatments being very small and no visual symptoms appearing. Boron deficiency, to the tomato at least, was found also on land on the slopes of Mount Kenya above Naro Moru. As Boron deficiency was suspected in a coffee nursery near Kisii, a test was undertaken on soil from the nursery but, despite a high degree of replication in the experiment, no sign of Boron or any other deficiency was found.

The four samples from the Menengai area were found to be deficient in copper. As a similar lack had been indicated previously near Njoro, Rongai and Kampi-ya-Moto, a series of experiments is now under way to try to find out how far the copper-deficient soils extend, what crops are likely to be affected, and what responses might be expected to applications of copper sulphate. The tests are confined to six replicates of the comparison "complete nutrient" *versus* "complete nutrient without copper". To date, 23 tests from the area have been completed, 18 are in progress and a further 41 projected. The actual number of tests ultimately undertaken naturally will be determined by the ease with which the boundary of the area is delineated by the tests. It is already obvious that for the tomato the deficient area does not extend far to the north or east of Menengai Crater, but the limits to the west and south remain uncertain. Experiments with wheat in which copper has been added at varying rates to soils shown in earlier tests to be deficient in the element are in progress and the indications are that considerable increases in yield may be expected. One further instance of copper deficiency has been found on the forest edge on the South Kinangop in an investigation which was carried out following a report of poor growth of cauliflowers. In the pot tests, tomatoes and cauliflowers responded to much the same degree to additions of copper, but field conditions indicated that the physical state of the soil was contributing as much to the unsatisfactory growth of the vegetables as the mineral deficiency.

Estimates of the copper content of the soils being pot tested were obtained using the Aspergillus technique. In all cases where copper deficiency was indicated by the tomato, a low content was found but the reverse was not always true of samples taken in the Nakuru copper survey. North of Mount Menengai in the area of Ol Punyata Station and Lake Solai showed a low copper content though no response was obtained in the pot tests. The remaining samples taken for advisory purposes did not reveal any trace element deficiency. The multiplicity of sporadic deficiencies which pure growth measurement on some of the early Kenya pot tests seemed to indicate are now regarded with considerable reserve. In the light of accumulated experience in pot testing and of the refinements of technique now used, a deficiency is recognized only if an appreciable and significant growth check in the absence of the nutrient is accompanied by recognizable foliar symptoms of a deficiency in that nutrient.

A series of tests was carried out to study the effects on tomatoes of excesses of those nutrients known to be toxic to plants when present in quantities larger than those normally encountered in the soil. Symptoms similar to those produced in these tests have not been observed on plants used in the Webb/Hewitt tests so it seems unlikely that such toxicities occur in Kenya soils or that the Webb/Hewitt test indications so far obtained have been at all vitiated by the presence of nutrients in toxic quantities in any of the treatments.

Fertilizer Trials

(Mr. Boswinkle)

The fertilizer trials programme in African areas was continued in 1959, a total of 222 trials being carried through to harvest. These trials were distributed:—

Province	Exploratory Trials				Rates Trials				Total
	New		Residual or reapplication		New		Residual or reapplication		
	L.R.	S.R.	L.R.	S.R.	L.R.	S.R.	L.R.	S.R.	
Central	14	6	30	18	3	0	8	11	90
Coast	13	4	4	0	0	0	0	0	21
Nyanza	24	2	14	9	5	1	3	4	62
Rift Valley ..	6	0	4	2	3	0	2	0	17
Southern ..	7	6	9	9	1	0	0	0	32
Total ..	64	18	61	38	12	1	13	15	222

The advanced state of fertilizer investigations in Central Province is indicated by the relatively small proportion of new exploratory trials and the relative large number of rates trials now in the residual or reapplication phase. In Nyanza and Coast, continued preoccupation with the elucidation of the fertilizer requirements of a rather complex soil situation is reflected in the comparatively large number of new exploratory trials which were laid down in these Provinces, particularly in the long rains. Rift Valley benefited from the similarity of a number of soils in its African areas with soils which have been more intensely examined elsewhere. Consequently, a start has been possible on rates trials in Rift Valley without the necessity of undertaking the number of exploratory trials which have been necessary in other Provinces.

The results of the 1958 trials were analysed. As in 1957, the 48 successful Central Province long rains exploratory trials were mainly on potatoes and maize on deep uniform red loams derived from volcanic rocks. The greater proportion of these trials were residual or reapplication studies. The mean yields were:—

Fertilizer Treatment	Yield from New Trials		Yield from Residual Fertilizer		Yield after Reapplication of Fertilizer	
	with	without	with	without	with	without
			Potatoes, bags/acre			
N	38·1	34·8	—	—	34·1	31·2
P	39·6	33·6	28·5	27·2	44·2	40·3
K	42·0	41·9	38·7(1)	39·4	33·8	37·5
Lime	—	—	20·4(2)	17·4	—	—
Manure	40·6	32·3	34·0	30·9	63·5(1)	58·9
			Maize, lb./acre			
N	—	—	2,170(1)	1,782	2,419	2,408
P	—	—	2,500	2,357	2,007(1)	1,856
K	—	—	1,873(1)	2,078	2,807	2,804
Manure	—	—	2,629	2,329	2,090(1)	1,773

Note: (1) Results from one site only.
(2) Soils limed at rates near laboratory determined lime dressing needed to give a pH near 6.0

The beneficial effect of manuring both on potatoes and on maize and its comparatively large residual effect are apparent. Superphosphate also was beneficial, particularly when applied to potatoes, though the crop seems unable to make very much use of the residual from an application to an earlier crop. Overall, the application of nitrogen also benefited potatoes, though the effect was not general. Maize appears to benefit from this treatment only where yield levels are low. Potash application once again was ineffective or actually harmful. Insufficient satisfactory trials were available for a proper understanding of the conditions necessary for liming to be effective, though where it is effective the effects are spectacular. Under such conditions, liming enables a crop to germinate and to grow through to harvest when in the absence of lime, it may not even become established. At the same time, it is clear that where such conditions prevail the soils are extremely acid and that it appears that for liming to be effective, the application must approximate to the laboratory determined requirement for bringing the soil up to a pH of around 6. This involves dressings of the order of 8-9 tons per acre, the cost of which is very great. In consequence, the best use of these soils seems to be the growing of acid-loving crops such as tea. Food crop production on them should be confined to old hut sites and similar pockets of concentrated fertility which local cultivators know already as being good for cropping and which, in fact, are likely to be unsatisfactory for tea. The success of tea in many of the high acidity areas concerned has already been established by existing plantings.

The general benefits from manure and phosphate application and the less certain benefits of nitrogen for potatoes on the deep uniform red loams derived from volcanic rocks in Central Province were again apparent in the rates trials initiated during 1958. The mean main effects of these treatments in the 3^3 trials concerned are:—

Application	Yield in Bags/Acre		
	Nitrogen	Phosphate	Manure
Absent	54·0	51·8	52·8
Low level	57·8	57·9	59·4
High level	60·6	60·9	60·4

The mean responses fit the following Mitscherlich type response curves:—

Nitrogen.—$Y = 68.4 - 14.4 \times 10^{-0.089x}$ where Y is the yield in bags of potatoes/acre from an application of X cwt./acre sulphate of ammonia.

Phosphate.—$Y = 61.1 - 7.9 \times 10^{-0.545x}$ where X is the rate of double superphosphate application in cwt./acre.

Manure.—$Y = 60.6 - 7.7 \times 10^{-0.074x}$ where X is the rate of manure application in tons/acre. The constants 68.4, 61.1 and 60.6 in the three equations represent the maximum possible yields which, by the law of diminishing returns, it would be possible to obtain by application of sulphate of ammonia, superphosphate or manure under the general conditions of the trials. The form of the curves suggests that little advantage will come from applying more than the low level application of $1\frac{1}{2}$ cwt./acre double supers or 11 tons/acre manure to potatoes, but that distinct benefits can accrue from sulphate of ammonia applications at rates appreciably in excess of the high level of 3 cwt./acre used in the trials. Adequacy of nitrogen clearly is essential for the highest potato yields to be obtained.

The potato once more suffered from blight and, once again, isolated instances were observed in the exploratories of blight incidence having been reduced by potash application. However, this effect seems not to have found expression in improved yields through the use of potassic fertilizers.

The Central Province short rains trials once more were predominantly on beans, these being used to measure the residual effects of earlier fertilizer application. The average results obtained from comparable trials were:—

Fertilizer	Application Rates	Trials Group		
		Exploratories		Rates
		1st Residual Season	3rd Residual Season	1st Residual Season
Sulphate of ammonia cwt./acre ..	0	532	—	780
	1½	—	—	793
	2	558	—	—
	3	—	—	787
Double supers cwt./acre	0	554	637	636
	1½	—	—	834
	2	630	717	—
	3	—	—	890
Muriate of potash cwt./acre ..	0	690	—	—
	2	646	—	—
Manure tons/acre	0	512	673(1)	657
	11	—	—	807
	15	717	945	—
	22	—	—	895
Limestone (1) tons/acre	0	—	285	—
	2·45	—	475	—
	4·90	—	581	—
	7·35	—	676	—

Note.—(1) Result from one site only.

Residual benefits on beans are apparent from double supers, manure and lime application, these persisting to the third season. The mean phosphate and manure residuals in the rates trials again fit Mitscherlich-type response curves: $Y = 912 - 276 \times 10^{-0.548x}$ where X is the superphosphate dressing in cwt./acre and $Y = 1020 - 363 \times 10^{-0.021x}$ where X is the manure dressing in tons/acre.

The maximum potential yield from manure application (1,020 lb./acre) is distinctly higher than that from the phosphate application the season following the season of application of these treatments. The curvature factor 0.548 for the residual phosphate effect is strikingly close to that for the potatoes to which the phosphate was applied (0.545), suggesting that the availability of the residual phosphate at the time the beans were in the ground was not appreciably different from that of the applied fertilizer at the time the potatoes were in the ground. The differences between the gradient factors (276 for the beans and 7.9 for the potatoes) reflects partly a difference in the yield units used in the two equations (lb./acre and bags/acre, respectively) and partly a difference in the abilities of the potatoes and the beans to use that phosphate: a good dressing of super-

phosphate to potatoes has a much greater effect on that crop than its residual has on the succeeding crop of beans. The smaller curvature factor of the residual manure response for beans (0.021) than of the direct response for potatoes (0.074) suggests that the higher dressings of manure are not exhausted so rapidly as the smaller.

The correlation between laboratory determined availability of P and N in the soil and the trial results indications were recalculated on the basis of the additional information obtained in the 1958 exploratory trials. A 1 per cent significant correlation coefficient, $r = 0.80$ was found between phosphate response and chemically determined soil phosphate status by the Mehlich method, a 1 per cent significant coefficient, $r = 0.66$ between manure response and chemically determined soil phosphate, a 1 per cent significant coefficient, $r = 0.61$ between phosphate response and biologically available phosphate by the Cunninghamella test and a 1 per cent significant coefficient, $r = 0.69$ between manure response and biologically available phosphate. No significant correlation was found to exist between nitrogen or manure responses in the field and biologically determined nitrogen. The correlation coefficients found between phosphate response in the field and chemical and biological phosphate are close to the coefficients (0.78 and 0.62, respectively) reported in the 1958 Annual Report of the Chemistry Section for the comparison of greenhouse pot test indications of phosphate status and chemically and microbiologically determined soil phosphorus status. The absence of a correlation between nitrogen response in the field and biologically available soil nitrogen on the other hand is in striking contrast to the highly significant correlation coefficient, $r = 0.92$ reported in the 1958 Annual Report as existing between pot test and microbiological indications. This is presumed to reflect the importance of transient factors such as wetting and drying in determining nitrogen availability to plants in the field but which are not reflected in the relatively more constant moisture status and regular nitrogen supply regime of the pot test.

Other Central Province trials in 1958 concerned the fertilizing of millet, wheat, groundnuts, long rains beans and short rains maize and potato crops, but the number of these trials was insufficient for general conclusions to be drawn from them. Their results accorded well with the results of the main trials.

In Nyanza Province nearly all 27 successful long rains, 1958, exploratory trials were on maize and the 15 successful short rains trials were on beans. Meaned results in lb./acre are:—

Fertilizer Treatment	Maize			Beans	
	Long Rains			Short Rains	
	High	Low	Without	With	Without
Phosphate, direct	—	2,725	2,440	—	—
	4,040	3,844	3,543	—	—
Phosphate, residual	—	4,084	3,617	334	325
Manure, direct	—	2,903	2,262	—	—
	4,021	3,813	3,205	—	—
Manure, residual	—	3,786	3,915	349	311
Nitrogen, direct	—	2,895	2,789	—	—
	3,742	3,726	3,570	—	—
Nitrogen, residual	—	3,919(1)	3,146(1)	290	280
Potash, direct	—	2,801	2,751	—	—
Potash, residual	—	—	—	273	297

Note.—(1) Results from one site only.

Overall useful direct phosphate and manure and residual phosphate effects were recorded on the long rains maize crop despite a wide diversity of soils on which the experiments were conducted. The dark coloured soils around Sigor and Kabossan in the south-eastern part of the Bomet Division of Kericho yielded well without fertilizers and showed no response to fertilizer application: these soils are considered adequately fertile and not to require fertilizer treatment at the moment. The greatest responses to the effective fertilizers were on the more strongly coloured soils derived from granite. On these, yield increases amounting to 1,200 lb./acre from 1 cwt./acre double supers and 1,500 lb./acre from 7½ tons/acre manure are on record. The residual effects of prior fertilizer applications on beans were quite small.

The phosphate, manure and nitrogen relations of the rates trials fit the following Mitscherlich-type response curves:—

Nitrogen.—$Y = 3745 - 175 \times 10^{-0.99x}$ where X is the rate of sulphate of ammonia application in cwt./acre.

Phosphate.—$Y = 4238 - 785 \times 10^{-0.30x}$ where X is the rate of application of double supers in cwt./acre.

Manure.—$Y = 4129 - 924 \times 10^{-0.062x}$ where X is the rate of manure application in tons/acre and Y is in all cases the yield of maize in lb./acre. On average the yield potential of nitrogenous fertilizers on maize in Nyanza (3,745 lb./acre maximum) is distinctly less than of phosphatic fertilizers (4,238 lb./acre) or manuring (4,129 lb./acre) and the amount of nitrogen which on average maize seems able to use effectively is potentially small. The response curves for phosphate and manure resemble those for potatoes in Central Province much more closely than the nitrogen curve, though here again the slope gradients suggest that potatoes are a more effective user of added phosphate or manure than maize.

In Southern Province a great improvement in the value of fertilizer experimentation resulted from the extensive use for the first time in 1958 of Taboran maize. Some 55 trials, mainly on soils derived from the Basement Complex were successfully completed during the year, roughly half of them being in the long rains and half in the short. The means of the trials involving maize were:—

Fertilizer Treatment	Yield lb./acre		
	High	Low	Without
Phosphate, direct	—	1,563	1,356
	3,218	—	3,000
Phosphate, residual	—	1,807	1,498
Nitrogen, direct	—	2,518	2,133
Manure, direct	—	1,640	1,278
Manure, residual	—	1,913	1,392
	3,312	—	2,900
Potash, direct	2,165		2,165

Overall responses to double supers and sulphate of ammonia application at 1-2 cwt./acre and to manure application at 7½ tons/acre and residual effects from 1 cwt./acre double supers and 7½-15 tons/acre manure were again conspicuous. The heavier phosphate and manure applications were given in the moister parts of Machakos and the lighter dressings in the drier areas. The investigation programme aimed partly to determine the response pattern of the sandy loams derived from the Basement Complex. It became apparent that on the pale orange

and pallid variants, the effectiveness of phosphatic fertilizing can be predicted by the chemical determination of dilute acid soluble phosphorus on a soil sample from the site, indications below about 20 p.p.m. phosphorus going with field indications of phosphate response and of above 20 p.p.m. with its absence. These soils all benefit from nitrogenous fertilizers and from manure application. The dark orange and red sandy loams almost invariably respond to phosphate and manure and sometimes to nitrogen though as yet no basis of predicting the likelihood of benefits coming from nitrogen fertilizing has been discerned.

Most of the 13 successful Rift Valley Province trials in 1958 were concerned with measuring the residual effects of phosphate and manure. Insufficient data was available for response patterns to be discernible. New and reapplication trials in the Province again gave widespread responses to nitrogen, phosphate and manure. The 12 successful trials in Coast Province in 1958 suggested that the response patterns applicable to soils derived from Basement Complex rocks up-country applied also to the siliceous sediments of the coastal region.

Lime Trials

(Dr. L. A. Whelan)

The long-term lime investigation programme continued, though, at the request of the farm owner the trial at Kaptagat has been discontinued. The remaining three trials are now down to grass.

At Eldoret the sward, now in its second year, is showing satisfactory growth. Plots were graded in October for relative percentages of grass, clover, miscellaneous and bare soil. The ratios of grass to clover for all treatment levels were: —

L_0	L_1	L_2	M	P_0	P_1	P_2	−NK	+K	+NK
1·9:1	1·1:1	1·3:1	1·1:1	0·9:1	2·1:1	1·2:1	1·1:1	1·2:1	1·7:1

Sulphate of ammonia was applied during the year, but differential superphosphate dressings were last applied in 1958. Both these treatments favoured the grass relative to the clover, while the lime applications of 1953 had the opposite effect. The percentage of weeds was low, approximately 3 per cent, and was not affected by treatments.

In November the plots were scored for total growth and estimates are given below in terms of tons per acre: —

L_0	L_1	L_2	M	P_0	P_1	P_2	−NK	+K	+NK
3·8	4·7	5·2	4·3	4·9	4·8	3·8	3·7	4·0	5·8

There has been a distinct beneficial effect on total growth from both lime and nitrogen, but not from phosphate.

At Marindas the grass showed signs of deterioration during this third year. A cut was taken in August and a summary is given in terms of pounds per acre of green material:—

	L_0	L_1	L_2	M	Mean
P_0	2,709	2,265	2,339	2,319	2,408
P_1	1,533	1,398	1,761	1,398	1,523
P_2	1,929	1,472	1,398	1,849	1,662
P_3	2,218	2,252	1,560	2,124	2,039
−NK	1,560	1,647	1,408	1,391	1,502
+NK	2,635	2,047	2,117	2,457	2,314
Mean	2,098	1,847	1,764	1,924	

L.S.D. for NK at 1 per cent—485

The response to NK is highly significant. The significant response to lime obtained in 1958 has disappeared and has, in fact, been replaced by some yield depression. A survey of each plot was made at the same time for the amounts of grass, clover and weeds relative to each treatment level:—

	L_0	L_1	L_2	M	P_0	P_1	P_2	P_3	−NK	+NK
Grass ..	7	8	8	8	8	8	8	8	5	10
Clover ..	3	2	1	2	2	2	2	1	3	1
Weeds ..	9	6	4	5	8	6	6	4	6	5

There is an indication that lime has depressed both clover and weed growth but has had little effect on the grass. Residual phosphate has had no effect on grass or clover. Nitrogen has increased growth of grass at the expense of the clover. In view of the poor condition of the plots it is proposed to plough out the grass, resow and apply the lime reapplication differential in 1960.

At South Kinangop, the kale planted in 1958 was harvested in January, 1959. A summary of the yields is given below in tons per acre:—

	P_0	P_1	P_2	P_3	Mean	
L_0	2·06	10·92	11·53	11·81	9·08	±(·664)
L_1	3·76	13·31	12·11	13·99	10·80	
L_2	6·04	14·34	16·09	15·38	12·96	
M	4·90	12·44	11·45	12·38	10·29	
−NK ..	4·15	9·05	9·81	10·33	8·34	±(·469)
+NK ..	4·23	16·42	15·75	16·41	13·20	
Mean ..	4·19	12·74	12·78	13·37		
			±(·698)			

L.S.D.—	5%	1%
Lime ..	1·94	2·63
Phosphate ..	2·33	3·45
NK		1·86

The differential rates for N, P and K had been reapplied during 1958. There is a highly significant response to L_2. The response to L_1 falls short of signifi-

cance but it should be noted that this small dressing of 1½ tons/acre of limestone had been applied in 1954 and the effect on the soil is now beginning to wear off. All phosphate levels show highly significant responses and much greater responses than the responses with lime treatments, but no difference between levels. The response to the NK mixture is large and highly significant.

As the pH of the limed plots had dropped during the preceding year lime was reapplied in June to half the number of plots originally limed. The rates of reapplication were L_1 2,690 lb., L_2 5,280 lb. dolomitic limestone and M 2,400 lb. calcitic limestone per acre. The plots were sown to linseed and a grass clover mixture in July. Owing to the prevalence of weeds the plots had to be mown and the linseed sacrificed. In October the grass was scored for growth and a summary for the different lime treatments is given. In the table, R refers to relimed plots: —

L_0	L_1	L_1R	L_2	L_2R	M	M R
5	5	8	5	10	5	7

The figures show no response to the initial lime dressings, but a decided response where lime has been reapplied.

In the laboratory, an investigation was carried out into the capacity of limed and unlimed soils from three of the liming trials to produce nitrate under favourable laboratory conditions. The incubation method of Kresge and Merkle (*Soil Sci. Soc. Amer. Proc., 21,* 516-521 (1957)) was used. The method for determining alkaline permanganate soluble nitrogen used by the same authors was also used here. The soils were incubated for 12 weeks and the nitrate nitrogen estimated at the end of each fortnight during the incubation period. In the table below, the figures refer to the total amount of nitrate nitrogen produced per 2,000,000 lb. of soil. The figures for the distillation technique are on the same basis. Lime was applied at Kaptagat in 1953 and soil samples were taken in 1955 and 1957. Lime was applied at Kinangop and Marindas in 1954 and samples taken in 1957.

	Total N %	Nitrogen by incubation lbs.	Nitrogen by alkaline permanganate lbs.
Kaptagat 1955 unlimed	—	284	542
limed	0·20	360	524
Kaptagat 1957 unlimed	—	276	522
limed	0·20	328	540
Kinangop 1957 unlimed	—	352	632
limed	0·23	419	600
Marindas 1957 unlimed	—	407	710
limed	0·30	388	766

The results are also expressed as percentages of total nitrogen nitrified during the incubation period: —

	Kap. 1955	Kap. 1957	Kin.	Mar.
	%	%	%	%
Unlimed ..	7·1	7·0	7·7	6·8
Limed ..	9·0	8·2	9·0	6·5

The considerable differences between sites in the amount of nitrate formed and also the permanganate soluble nitrogen are directly related to the total soil nitrogen. Liming in the field has increased laboratory nitrification in the Kaptagat and Kinangop soils, but not in the Marindas soil: this difference may be due to the greater elevation and colder climate at Marindas. There appears to be no relationship between liming and the permanganate soluble nitrogen.

Incubation was continued for a further eight weeks with little change in the relative rates of nitrification. The soils were then left for four days on the laboratory bench and incubated for ten days. The amounts of nitrate nitrogen produced per fortnight and averaged over all sites and treatments for the first fortnight, the following 18 weeks (where rate of nitrification was fairly consistent) and the last fortnight were 120, 46 and 90, respectively. This steep increase in the last fortnight which applies to all three sites is probably a result of drying the soils and is in line with results obtained by other local workers on the effect of drying and wetting of soils on CO_2 production.

Relationship Between Phosphate Response and Certain Soil Characteristics

The indirect relationships found by H. F. Birch (1953) (*J. Agric. Sci., 43,* 229) between phosphate response, and soil pH and citric acid soluble silica for a wide variety of unlimed East African soils were found also in this investigation to apply to limed soils.

Soil samples were examined for each year of the cereal cycle from plots given the different lime and superphosphate treatments. Results were similar for all years from the four sites, but the figures given in the table below refer to mean values for the full number of years under cereals and to the Kaptagat and Kinangop sites only. The responses refer to the P_3 level (400 lb. double superphosphate per acre per year) and are expressed as percentages of the yields on the P_0 plots which are given as pounds per acre. The lime treatments are arranged according to the pH attained:—

	Kaptagat (Means of 4 Seasons)					
Symbol	L_0	L_1	H	L_2	M	L_3
Liming rate lb./acre ..	Nil	4,400	6,420	8,150	13,000	17,740
P_0 yield	502	743	822	779	840	873
Percentage P_3 response ..	312	127	107	67	41	34
pH	4·9	5·1	5·4	5·6	5·9	6·0
SiO_2 ppm	92	97	106	105	122	118

	Kinangop (Means of 4 Seasons)			
Symbol	L_0	L_1	M	L_2
Liming rate lb. acre/	Nil	3,400	3,000	6,000
P_0 yield	553	676	742	703
Percentage P_3 response	110	71	63	63
pH	4·9	5·5	5·8	5·9
SiO_2 ppm	51	60	62	69

There is general agreement at both sites between rise in pH and increase in citric soluble SiO_2 and both of these show an increase in relationship to phosphate response. As Birch has pointed out the pH is a useful indication of the magnitude of the response that may be obtained from the phosphate application.

Wheat Chemistry

(Mr. H. C. Hodgson)

The experiments started in 1958 in the search for a suitable supporting medium for the electrophoretic separation of gluten proteins were continued. The work in 1958 had indicated the general unsuitability of materials containing free hydroxyl groups on which the gluten protein constituents become adsorbed through hydrogen bonding. This phenomenon influenced to some extent the electrophoresis of all proteins on such conventional bridges as paper, starch and gums but is particularly marked in the case of gluten. The problem was, therefore, to obtain material not containing hydrophilic groups but which, by its "wettablity" or physical structure could retain aqueous buffer solutions in a continuous film or volume and from which the various migratory fractions of gluten could be extracted or on which they could be estimated *in situ*. The most promising substance to fulfil these conditions was considered to be sponge rubber of fine porosity and with inter-connecting pores. This material had the additional advantage of enabling separations to be performed on a semi-micro scale, thus providing sufficient fraction quantities for further experimentation.

The method in which the sponge rubber is used is a modification of a technique devised by U.S. workers. It involves application of an electrical potential through a series of small sponge rubber blocks soaked in an acid buffer and contained in a perspex trough cooled top and bottom with a stream of iced water to reduce heat convection in the trough to a minimum. On completion of a run, the individual sponges are removed one by one from the trough and their contained solutions are then extracted by placing each sponge in the barrel of a hypodermic syringe and squeezing it with the syringe plunger. The trough is some 30 cms. long and contains some 40 sponge blocks, giving the same number of solution fractions. The method is at a disadvantage compared with paper electrophoresis in that the latter, an indicating dye can be applied direct to the dried paper for the determination of the electrophoresis pattern. Again, with the sponges the dimensions and locations of the concentration peaks cannot be determined with absolute precision. The extract from each sponge is estimated by the micro Kjeldahl procedure. The distillation and titration stages of the analysis proved tedious and time-consuming and so have been abandoned in favour of the Conway micro diffusion technique. Direct determination of the protein in the extracts by ultra-violet spectrophotometry also was tried, but this has given poor agreement with the corresponding Kjeldahl nitrogen figures.

The electropherograms obtained have shown two or more major fractions of relatively low mobility, preceded by a more mobile group of lesser components to occur in gluten proteins. The recovery in the electrophoresis peaks concerned of the material applied to the bridge, however, has been unsatisfactory in most cases. This is attributed to selective adsorption of the protein on filler materials which it has been found are incorporated in commercial sponge rubber such as that used for making the bridge. The true pattern, therefore, is likely to be more complex. Despite this, the present indications are that the protein constituents of different glutens differ from one another and that the use of adsorbent free rubber will make feasible an accurate assessment of these differences. Rubber of the desired properties is now being sought.

Wheat Maturation Trials

(Mr. H. C. Hodgson)

In continuation of the field trials programme in connexion with wheat quality investigation, a trial was laid down at Ol Joro Orok with the object of comparing the effect on protein content and dough characteristics, of harvesting at various stages of maturity under various weather conditions. Harvests were made at weekly intervals from an estimated three weeks before to three weeks after ripening. Two sowings separated one from the other by an interval of a month had been made in the hope of getting a difference in harvest conditions between the times when the two sowings would ripen and during each of the maturation periods so obtained some of the heads were protected from the weather by polythene sheet covers and some were left unprotected from the first (i.e. three weeks pre-ripe harvest) onwards. The trial was undertaken on Regent wheat, being a wheat locally grown seed of which was considered now to be in a condition which would make it sensitive to its environment.

In the late sowing, the changes in the grain during ripening and post-ripening period appeared to be associated both in the covered and uncovered heads with a build-up of dough strength from just below 50, one to two weeks prior to ripening to above 60, one to two weeks after full ripeness, followed by a sudden collapse. Covering the heads appeared to hasten the dough strength build-up and subsequent collapse. No similar sequence of events was discernible in the dough strength changes over the ripening period of the early sowing. Here, the dough strength values fluctuated erratically around 50 in the case of the covered heads and between 40 and the high 50's in the case of the uncovered heads.

Records of temperature and relative humidity were maintained among both the covered and the uncovered heads by recording thermohyrographs during the harvest periods and from the charts the mean daytime temperatures and relative humidities were determined day by day. The night temperatures quickly fell to fairly constant minima and night humidities quickly rose to near saturation values each night, and so these periods of constant low temperature and high humidity are excluded from the discussion. The covers had only a limited inconsistent effect either on temperature or humidity. The temperature during the pre-ripe period of the early harvest fluctuated considerably between 37° F. and 54° F. (38° F. and 56° F. covered) but thereafter steadied somewhat and tended to rise during the late harvest pre-ripe period from 46° F. to 60° F. (43° F. to 55° F. covered), falling thereafter to around 40° F. before recovering at the very end of the record period. The humidity fluctuated inversely with the temperature, ranging erratically between 40 per cent in the warm weather and 80 per cent in the cool (38 per cent and 85 per cent covered) in the early harvest period and falling fairly steadily from 48 per cent to 23 per cent (55 per cent to 30 per cent covered) as the weather warmed up during the late harvest pre-ripe period. The fall in temperature towards the end of the harvest season was matched by the rise in relative humidity to around 70 per cent and the final rise in temperature with a corresponding drop in humidity. The fluctuations in mean daytime temperature and relative humidity were directly related to the local incidence of rain as given on the East African Meteorological Department monthly records for December, 1958, and January, 1959. The periods of low temperature and high humidity during the early harvest period corresponded with periods of showery or stormy weather in the locality while the intervening warmer less humid periods and the warmer more stable temperature and humidity conditions during the pre-ripe period of the late harvest corresponded with periods of dry weather. During the cool moist spell towards the end of the late harvest there was further local rain, but this gradually decreased as the temperature rose and the humidity dropped at the very end of the record period.

The fluctuations in dough strength of the early harvest did not follow the fluctuations in temperature, humidity or rainfall except that the considerable build-up of strength from about 40 to about 60 in the last week of sampling may have been connected with the rising temperature, fall in humidity and onset of dry conditions which had started then. The build-up of strength during maturation in the late sowing may be related to the sustained warm, dry weather then prevailing. Though the subsequent collapse in strength of the uncovered wheat might be related to the drop in temperature and rise in humidity which was recorded towards the end of the trial, the fact that the collapse in strength of the covered wheat occurred several days before the onset of the cool conditions suggests that the cause of the collapse is quite different. These observations lead to the suggestion that at Ol Joro Orok fine dry weather is necessary for a smooth build-up of dough strength, but even under these conditions harvests must not be delayed. Otherwise, changes in the intrinsic characteristics of the grain going with the development of over-ripeness will lead to a rapid decline in strength. The operation of these two factors may have been the cause of the many inconsistencies in the results of past wheat quality trials and is likely to be an intrinsic hazard in the Kenya Highlands wheat harvests. Wheat growers, even in the lower, warmer, drier areas where harvest weather is more reliable, need to keep well up on their harvests if they are to get grain with the highest dough strengths. Where weather is unsettled during the maturation period it seems that the build-up of dough strength once the weather settles can be extremely rapid and the period taken for the grain to reach its peak quality becomes quite short. Under these conditions it seems imperative for the farmer to press on with the harvest with the maximum possible urgency as soon as there is a break in the weather.

The crude protein contents fluctuated during ripening, but tended to rise in the early maturation periods and to settle down once the grain matured to values around 13.2 per cent for the early and 14.2 per cent for the late sowing. The covered and uncovered heads of each harvest rose and fell in unison with one another though the differences between the two in protein content were neither large nor consistent. At all stages of ripeness the crude protein content of the late sowing was about 1 per cent higher than that of the early sowing. No connexion was apparent between protein content and dough strength.

L/P ratios also fluctuated erratically though the covered and uncovered heads of each harvest rose and fell in unison. The L/P ratio of the early sowing fluctuated between 0.74 and 1.28 and was generally between the comparatively narrow limits of 1.04 and 1.22: that of the late sowing rose and fell between limits as wide as 0.64 and 1.69.

Study of the changes during maturation was complicated by the unevenness with which the wheat ripened. The harvest at each sampling time was a mixture of grains at several different stages of ripeness. More clear-cut differences in dough characteristics might have been obtained had a grain-by-grain assessment of its maturity state been possible at each harvest and had sufficient grain in each maturity class so obtained resulted for dough investigation purposes. Additionally, advantages would have come from extending the harvest period particularly in the pre-ripe period, so enabling the protein and dough strength changes to be followed from the low values which go with extreme immaturity of the grain. With the objects of obtaining such additional information on dough characteristic fluctuations during maturation and of covering a different range of harvest conditions from those prevailing in the 1958/59 season, a modification of the 1958 trial was laid down in 1959 for harvesting in 1959/60. In this trial the number of sowing dates was increased to three and the period over which samples were collected for laboratory determination was extended earlier into the grain maturation period.

Crop Product Development

(Mr. H. C. Hodgson)

Citrus Juice.—Thirty-three samples of lemons were processed and the juice pasteurized, preserved with sulphur dioxide and despatched to Messrs. Schweppes Limited, London, for assessment. These samples originated largely from the areas which the 1958 samples had shown to have most promise for the production of lemon juice and a desirable quality. The samples were from monthly harvests from these areas and were taken with the object of determining the extent to which quality fluctuated from season to season and the best time of the year at which to take fruit for juicing.

Essential Oils.—A sample of geranium oil distilled from the Reunion plantings at Scott Agricultural Laboratories and submitted to the Tropical Products Institute received a more favourable trade report than any samples previously submitted. This may be due in some measure to the care taken in selecting bright sunny dry weather conditions for the harvest. At the same time, no Kenya geranium oil, even from Reunion plants, has yet been produced with the perfumery characteristics recognized by the trade as true Bourbon geranium. Even so, there appears to be a good firm market for Kenya produced geranium oil of good quality, selling in its own right, whether this oil originates from Reunion plants or the original Kenya stock. The price offered for Kenya oil and the firmness of demand are sufficiently attractive for it to be well worth while expanding the production of Kenya geranium oil, and new growers taking up the crop. The Reunion geranium has several cultural advantages over the Kenya type: it has a more erect bush habit which makes it better suited to row cultivation, it strikes more easily in the field from cuttings and it is a more vigorous grower. The Reunion has a distinct yellowish green (as distinct from the greyish green of the Kenya) tinge to its foliage and the oil particularly the less volatile fraction, has a marked greenish tinge, even when distilled in glass, which the Kenya geranium does not display.

Eleven citrus peel oil samples were purified and forwarded to the Tropical Products Institute, again under the citrus development project of the Department.

Sufficient trade interest has been shown in the oil of Mexican Marigold (Tagetes *minuta*) following the submission of samples in 1958 for the trade to call for further samples in commercial quantity.

Nitrogen in Rainfall Studies

The nitrogen in rainfall studies were wound up in 1959 after ten successive years of determinations. The year's results were:—

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Rainfall	0·69	0·61	5·01	2·63	4·34	0	1·08	1·81	0·49	0·96	11·70	2·42
Rainfall, mean of 10 years	1·96	2·03	2·41	8·06	8·22	1·50	1·11	0·80	0·66	1·73	4·83	2·55
Rainfall, mean of 33 years	1·85	2·00	4·31	8·70	6·39	1·83	0·60	0·09	0·96	2·01	4·46	3·01
Rainy days	4	4	12	13	17	0	6	8	6	4	21	6
Ammoniacal N added by rain lb./acre ..	·025	·096	· 500	·252	·266	0	·180	·042	·013	·024	·249	·090
Ammoniacal N added by rain lb./acre, mean of 10 years ..	·113	·196	·255	·543	·560	·072	·069	·071	·067	·241	·418	·210
Ammoniacal N added by rain lb./acre per inch of rainfall ..	·036	·157	·100	·096	·061	—	·167	·023	·027	·025	·022	·037
Ammoniacal N added by rain lb./acre, mean of 10 years ..	·067	·097	·106	·067	·067	·048	·062	·091	·101	·140	·085	·160

	1959	Mean over 10 years
Total rainfall	31·74	35·86
Total addition of ammoniacal N lb./acre	1·737	2·804
Lb./acre per inch of Rainfall—		
1959	·056	
1958	·057	
1957	·075	
1956	·102	
1955	·101	·078
1954	·089	
1953	·072	
1952	·064	
1951	·095	
1950	·064	

It is clear that an average fall of 1 in. of rainfall adds only between 1/20th and 1/10th of a pound of ammoniacal nitrogen per acre. Results of the first year of investigation (Annual Report, Chemistry Section, 1950) showed that the average increment of ammoniacal nitrogen per inch of rainfall at other stations as widely scattered in Kenya as Kitale, Ol Joro Orok and Embu was within the same range and that at none of these centres was the rate of nitrate nitrogen addition higher than a quarter of the rate of ammoniacal nitrogen addition.

The gentle rain and mists which are typical of June and July at Scott Agricultural Laboratories on average contained rather less ammoniacal nitrogen than the more thundery rain which falls during the rest of the year. Again, the relatively heavy and persistent rain of April, May and November had a somewhat lower ammoniacal content than the thundery showers which heralded the coming of the long rains and which reach a second peak in the short rains. Even so, the maximum average monthly contribution of ammoniacal nitrogen in rainfall exceeds half a pound per acre only during April and May and the overall contribution is less than three pounds per acre per annum.

The investigation is now discontinued.

Analytical Data

The following analytical data obtained during 1959 is of general interest:—

FOODSTUFFS AND PLANT TISSUES

COMMODITY	Moisture %	Oil %	Crude Protein %	Fibre %	Ash %	
Barley						
Proctor	14·0	—	—	—	—	N 1·40%
Research	15·7	—	—	—	—	N 1·43%
Brachiaria grass	82·0	0·4	4·0	4·4	2·6	
Brewers grains	11·6	5·7	16·4	8·6	6·4	CaO 0·78% P_2O_5 0·30%
Brewers yeast	—	—	—	—	—	HCN 5 ppm.
Castor						
In-bred Cineron ex S. Africa	—	46·7	—	—	—	
Once grown Cineron	—	44·7	—	—	—	
Once grown Cineron dark seed	—	46·9	—	—	—	
Once grown Cineron light seed (probably immature)	—	8·1	—	—	—	
Citrus Juice						
Lemons	—	—	—	—	—	Acidity as cit. acid 6·2% W/V.
Perrins	—	—	—	—	—	8·4% W/V.
Coriander seed	—	15·3	—	—	—	
Cotton seed hulls	11·4	2·9	4·3	47·0	2·8	
Doum Palm nuts	9·1	11·1	4·2	26·4	1·3	
Dried skimmed milk	8·5	0·4	29·6	0	8·0	
Fish meal	17·0	2·7	67·0	0·9	10·9	CaO 0·53% P_2O_5 2·21%.
Glusidia maculata						
Leafy material	57·4	1·7	8·7	8·6	—	CaO 0·3% P_2O_5 0·5%.
Grass dry	10·5	1·2	3·5	34·9	10·4	CaO 0·08% P_2O_5 0·31%.
Grass wet	85·6	0·4	2·9	3·6	2·0	
Ground Nuts						
Asiryomwetundia	—	51·8	—	—	—	
S.720	—	47·5	—	—	—	
Indian Almond (*Terminalia Catappa*) leafy material	68·5	0·9	4·1	4·9	—	CaO 0·4% P_2O_5 0·5%.
Jaggery	8·9	—	—	—	—	Sucrose 74·2% Invert Sugar 10·4% Sol. non-sugars 5·5%. Insolubles 0·9%
Kale	7·2	2·8	20·6	13·9	13·3	
Lucerne						
Dry	10·5–12·6	1·5–2·6	13·9–20·7	24·3–30·4	9·8–10·6	
Green	72·4	—	6·4	8·4	—	
Meal, Hairy Peruvian	8·4	2·5	20·1	25·2	10·6	
Meal, Hunter's River	8·9	2·5	21·8	23·7	11·5	
Meal, Provence	7·5	3·0	22·0	24·3	12·5	
Lupin seed	—	—	—	—	—	Alkaloid 0·16–0·37
Maize meal	—	—	—	1·44–1·62	—	
Oat						
Hay Milled	16·0	2·9	10·9	22·4	12·8	
Silage	78·7	0·9	1·8	7·5	2·2	
Pannicum Colaratum var. *Makarekariensis*	75·8	0·8	3·2	7·3	1·9	
Pea haulm	11·7	1·1	14·4	30·7	6·7	
Pombe residues	30·3	2·2	12·0	7·3	3·2	CaO 0·30% P_2O_5 0·22%

Foodstuffs and Plant Tissues

Commodity	Moisture %	Oil %	Crude Protein %	Fibre %	Ash %	
Pyrethrum Leaves						
Fertilized with phosphate	—	—	—	—	—	P_2O_5 1·47%
Not fertilized with phosphate	—	—	—	—	—	P_2O_5 1·44%
Rape seed	—	40·7	—	—	—	
Russian Comfrey	4·5–13·7	1·0–2·1	21·2–22·0	7·7–10·2	29·3–31·1	
Rye cake	9·2	9·4	26·3	13·9	—	
Silage	75·0	2·2	9·3	8·9	3·1	pH 6·0 CaO 0·22% P_2O_5 0·26%
Silage top layer	70·0	0·5	3·2	9·9	3·8	pH 5·6 CaO 0·22% P_2O_5 0·14%
Silage bottom layer	73·6	0·8	2·9	9·0	3·4	pH 5·7 CaO 0·20% P_2O_5 0·20%
Sorghum	19·4	1·4	10·2	5·9	2·0	CaO 0·39% P_2O_5 0·51%
Stock feed	42·4–56·4	10·5–13·3	5·5–8·3	5·0–5·1	2·2–3·1	
Sunflower Seed						
Seed	—	25·9–26·0	—	—	—	
Seed, black	—	28·4	—	—	—	
Seed, striped	—	23·2	—	—	—	
Seed, large heads	—	26·4	—	—	—	
Seed, small heads	—	24·3	—	—	—	
Wattle bark	11·7	—	—	—	—	Total extractives 45·7% Soluble solids 43·5% Non-tannins 10·1% Tannins 33·4%
White maize and lima bean silage	76·8	0·3	1·9	6·8	1·7	
Yellow maize silage	77·7	0·5	1·3	5·5	1·8	

Manures, Fertilizers and Mineral Supplements

Commodity	Moisture %	N %	P_2O_5 %	K_2O %	Ash %	
Agricultural lime	0·83	—	—	—	—	Acid insoluble 2·73% CaO 50·1% MgO 0·5% MnO 1·2% Sesquioxides 3·5%
Boma manure	20·7–38·2	0·95–1·15	0·51–0·55	1·43–1·95	—	
Cattle yard manure	63·4	0·56	0·75	0·93	—	
Deep litter	—	2·10	3·51	2·76	—	
Fish meal	—	10·0	12·6	—	—	
FYM	64·2	0·75	0·33	0·06	9·1	CaO 0·66%
FYM bottom of heap	—	1·47	1·72	4·44	—	
FYM top of heap	—	1·75	1·60	3·96	—	
Geranium distillation residues	98·2	0·14	0·01	0·37	0·7	
Geranium waste	—	0·66	0·12	0·74	—	
Nitrate of soda	0·15	15·4	(as nitrate nitrogen)			
Pig manure	66·4	0·92	1·71	1·20	—	
Poultry manure	52·9	1·33	4·03	1·61	—	
Seychelles Guano	5·2	—	26·8	—	—	
Sisal residues	18·2	1·1	0·24	0·98	—	
Sludge, fine constituents	20·0	2·32	1·74	0·25	—	
Stock feed lime	0·4	—	—	—	—	CaO 46·2%
Sulphate of potash	1·86	—	—	50·9	—	
Super phosphates	3·1–7·2	—	—	25·7–44·8	—	

Publications

"Iodine and Copper Uptake by Soil Organic Matter". J. M. Northmore. *Nature, 183* (1959), 1309.

Acknowledgements

Generous American assistance continued to be made available in the form of trained personnel and the provision of equipment. The contribution of I.C.A. to the advancement of land use investigation in Kenya has been notable. Finally, the co-operation of farmers both large and small in permitting us free access to their property, in discussing farming matters, in allowing us to take soil, plant and crop samples from their farms and in sending in samples themselves and of the trade in providing advice, literature and materials continues to be generous.

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ANNUAL REPORT OF THE SENIOR PLANT BREEDER, 1959

I—Review of the Year

Most districts enjoyed a better wheat season in 1959 than for a number of years. There was less rain than usual after planting and stem rust was slow to develop in the earlier areas although it appeared rather strongly in the higher districts, particularly the Kinangop, at the end of the season. Brown leaf rust was again fairly prevalent but not damaging to the marked extent experienced in 1958. On the other hand it was a season in which yellow rust in the ear was more severe than for a number of years. Barley also enjoyed a good season; the drier conditions led to rather less leaf disease than of late.

TABLE 1—NJORO RAINFALL, 1959 (INCHES)

Month	1959	30 Year Average	Month	1959	30 Year Average
January	1·94	1·04	July	3·75	4·37
February ..	1·08	1·37	August ..	1·54	4·95
March	2·97	2·73	September ..	3·64	2·75
April	2·99	5·34	October ..	1·35	1·98
May	8·38	4·62	November ..	3·57	2·60
June	2·73	3·30	December ..	0·84	1·82
			TOTALS ..	34·78	36·87

For maize there is a drop in the estimate of yield, due to the drier season. There is little to say on maize crops, but the expanded section on maize breeding in this report indicates the increased level of activity being devoted to this important crop. The continued success of the new stock resistant to Tropical American Rust developed at the coast is very satisfactory, and results with Taboran maize in the Machakos programme are specially encouraging.

The most significant point this year, from the aspect of development, was the grant of special funds under a Colonial Development and Welfare Scheme for additional work on wheat rust research and to launch the proposed expansion of maize breeding based at Kitale. Additional facilities are to be provided under these grants at Njoro, Kitale and Kakamega and the recruitment of extra staff was carried out at the end of the year.

Meanwhile, 1959 saw further additions to the facilities at Njoro under the original development scheme; these now more or less complete this particular phase and the accent turns to consolidation for the seasons ahead. The need for this is specially emphasized by experience this year with the newer races of stem rust when, in spite of a generally light year for rust, extremely heavy attacks built up on the breeding material at Njoro. In the advisory notice on the choice of wheat varieties for 1960, it has been necessary to remind farmers that the general excellence of crops in 1959 must be viewed with reserve when considering plans for the new season. This same reserve could also define the outlook on the breeding material at the present stage; this point is developed in the appropriate detailed section of this report. (Section III.)

Finally, it is to be recorded that senior members of the section made a number of successful overseas visits during the year. The Senior Plant Breeder has been to Central and South America, and the plant breeder in charge of maize at Kitale has been to the U.S.A. and Central America; these were study

visits made under the aegis of the Rockefeller Foundation and the International Co-operative Administration. Short but useful visits were made by the plant breeder and pathologist from Njoro to Turkey, for the F.A.O. meeting of Wheat and Barley Breeders, and to Ethopia. These various visits are a very considerable stimulus to the staff and should help considerably in the solving of the many difficulties that are involved in cereal breeding in Kenya.

II—Survey of Field Crops

The wheat acreage has risen by 21,000 acres in 1959, as shown by the figures in Table 2, so that the marked drop in the years 1955 to 1958 has been partly regained. The successes achieved almost certainly indicate a further rise in 1960. The rise in 1955 was in fact due to the increased yields of 1954, but this time the yields of 1959 are higher than before as can be seen from the table.

Maize acreages, so far as European production is concerned, have continued the fall apparent for a number of years and the figure for 1959 is a reduction of 59,000 acres since 1954, approximately 35 per cent. This is a decline on grounds of economics whereas that in wheat had been due to loss of confidence due to low yields from disease.

Table 2—Cereal Acreages, 1954-1959

Year	Wheat		Maize		Barley		Oats	
	Acres '000	Bags/ acre	Acres '000	Bags/ acre	Acres '000	Bags/ acre	Acres '000	Bags/ acre
1954..	291	5·10	174	9·11	29	7·30	22	7·02
1955..	345	3·93	158	7·89	24	6·62	19	6·72
1956..	316	4·43	166	7·67	42	7·29	25	7·85
1957..	239	4·78	167	8·04	52	6·67	26	6·88
1958..	235	4·56	124	9·37	56	6·70	21	6·86
1959..	256	5·54	115	9·28	39	7·69	19	7·70

(Figures are taken from the latest Board of Agriculture statistics: bags refer to 200 lb. net for wheat and maize, 180 lb. for barley and 150 lb. for oats.)

Varieties

The main wheat varieties currently grown are shown in Table 3, which also includes the acreages for the three previous years. The changes in acreage each year are the result of experience by farmers and advice on the choice of varieties in the yearly broadsheet. (*vide* "Cereals for 1959/60" by H. C. Thorpe and G. E. Dixon, published in the local Press, and K.I.O. Fortnightly No. 475 of February, 1959).

The trend to a wider spread of varieties reported last year has continued, but with some pronounced changes in popularity. The rise of 358 and 363, was to be expected, as these varieties have yielded consistently well and are suited to the middle altitudes. Sabanero has temporarily retained its position but is likely to continue to decline again in acreage, having rusted consistently. The most notable decline however is that of D. C. Ceres R64, which is now a minor variety yet was second in popularity only last year. Regent fell similarly from 5.8 per cent to a mere fraction; these changes followed the disastrous attack of brown leaf rust suffered in 1958 and mean a great reduction in the proportion of hard wheat being produced. From an acreage of 20 per cent last year, the hard

wheats fell to about 3 per cent for 1959. Another change of significance is the decline of the 362's which begin now to be displaced by the new bird group of varieties released for 1959 and already totalling 4.8 per cent of the acreage. The better baking quality of some of the bird group, notably Dove and Plover, is an encouraging point.

TABLE 3—WHEAT VARIETY ACREAGES, 1956-1959

Variety	1956	1957	1958	1959
	Per cent	Per cent	Per cent	Per cent
358	0·8	3·0	6·2	10·8
Sabanero	21·7	25·4	9·5	10·7
1066	7·6	9·6	7·9	9·9
363	—	1·1	4·3	9·0
362's	1·3	7·4	11·1	8·6
Baby Equator	11·5*	12·7*	7·9*	7·0
H.462	—	—	3·3	5·6
Birds (white grain)	—	—	—	3·3
Hopeful	—	3·4	4·8	2·9
131	11·0	10·1	3·4	2·9
D.C. x Ceres (R64)	8·1	5·5	10·1	2·8
Birds (red grain)	—	—	—	1·5
Africa Mayo	—	—	—	1·1
Other varieties	38·0	21·8	31·5	23·9
	100·0	100·0	100·0	100·0

FOOTNOTES:

(*a*) Figures for Baby Equator in the years marked also include Equator.

(*b*) Bird varieties with white grain comprise: Curlew, Eagle, Hawk, Buzzard, Quail. Those with red grain are: Dove and Plover.

The barley acreage has fallen and with it there appears to have been some stabilization of varieties, though figures comparable to those for wheat are not known. Research and Proctor continue to supply all malting requirements and there has been no call for No 5 as a malting variety so far. These three all give satisfactory yields for feed purposes and Carlsberg also. Herta, Heimdal and Kenia have now virtually disappeared, but Prior continues in the drier areas.

Oats continue to be unsatisfactory, due to rust limitations. Lampton and Grey Algerian remain as the standard types for feed and porridge respectively, with RL 1734, and to some extent 3003F, as additional feed varieties.

Of the two synthetic maizes, that from Njoro continues in popularity for certain areas, but that from Kitale has been disappointing and is disappearing.

DISEASES

A fuller statement of the cereal disease position is given in the Report of the Plant Pathologist which follows this report. However, certain general comments are necessary here in relation to the sections on breeding which follow.

As already mentioned stem rust of wheat was less active than for a number of years, so far as the country at large was concerned. There was however a decided change in composition in that identity tests showed a marked dominance by races K13 and K18, which correspond more or less to international races 42 and 40 respectively. At the same time race K19 (international 189) was also active and constitutes a strong threat to a wide range of varieties.

Brown leaf rust was not so damaging as in 1958, but the attack that year has led to the virtual elimination of the more susceptible varieties. Yellow rust was specially active as an ear rust at the higher altitudes and 1066 was damaged quite considerably on some farms. Co-operation with the European Yellow Rust Survey organized from Holland means that identity test results for races of this rust in Kenya are awaited with special interest. The resistance of the 362's and the bird group of varieties, which derives from Equator, continues to be extremely satisfactory.

Barley leaf diseases were not so severe as they have been of late and this problem seems likely to fall back into place. Hope of control by breeding seems doubtful, at least so far as the near future is concerned, but a more hopeful outlook prevails from the seed dressing experiments carried out by the Senior Plant Pathologist.

III—Breeding—Wheat, Barley and Oats

Breeding work is based at Njoro, with Molo as a special high altitude site; out-station facilities are then available for trials and observation work at Kitale, Eldoret, Rongai, Ol Joro Orok, Kinangop and Naro Moru, with Ol Joro Orok taking over multiplications from Molo.

Before reviewing progress in the various aspects of the programme, the point is made that further expansion more than doubled the amount of material on hand this past year and resulted in a total of over 16,000 plots being grown at Njoro during the year. To this must be added the high altitude sowings at Molo and Ol Joro Orok, a further 1,000 plots.

New Accessions and Crosses

The large collection of wheats from the Rockefeller Foundation in Mexico in 1958 was heavily culled this year on rust and other features and some 700 cultures, representing 150 original lines, are being continued. The most valuable material is that based on Cajeme 54, Wisconsin 245 and Frocor; the Wisconsin will be mentioned again later.

From the original Colombian collection of 1956, 14 lines are now in the initial stages of multiplication. A fresh and very much larger collection of 7,500 wheats was received this year, again from the Rockefeller Foundation in Colombia, and this produced a wide range of types and levels of disease resistance. Some 500 lines are being continued and this severe reduction is an indication of the heavy stem rust attack suffered by much of the material. The severity of attack at Njoro in 1959 has already been mentioned earlier in this report, and the planting of susceptible varieties as field surrounds and infector rows was undoubtedly instrumental in achieving this very heavy selection pressure.

A number of other accessions were received for test during the year and, of the 159 wheats grown, 16 were carried forward for further investigation as possible parents. It is notable that in this range of accessions, there were a number of examples of other related species but these all suffered severe stem rust damage.

The large new back-crossing programme, involving 188 lines of known stem rust resistance and five wheats of local merit, was carried forward a further two stages and reached the second back-cross. The first sowing, planted in January, developed little rust, but that in June became extremely heavily attacked at the end of the main season. In this latter sowing, results are extremely disappointing, in that remarkably little sign of segregation for resistance has been observable and general levels of infection were uniformly high. The series of crosses

involving Regent as the recurrent parent produced less rust than the others confirming that this Canadian variety has a valuable level of field resistance as observed in practice. The lack of resistant segregates in the programme as a whole is a serious setback, and an investigation on a limited portion of the material is now proposed to clarify the problem. Meanwhile the majority of the component lines, the 188 parents chosen as donors, maintain their observed resistance.

In addition to this main programme, 24 subsidiary crosses were made involving a number of selected parents, many of which contain rust resistance from other members of the *Triticineae*.

The main series of back-crosses of 1955-57 reached F_2 and F_3 and yielded some very promising material both on field performance and grain appearance. The outstanding parents for stem rust resistance are CI 12632 from Wisconsin, and Mida-McMurachy-Exchange (II-47-26) from Minnesota; to a lesser extent Egypt-Chapingo-Gabo and Kenya-Supremo-Yaqui from Mexico have also been good parents. This CI 12632 is quite outstanding and is derived from (Illinois 1 × Chinese)^2 × *T. timopheevi*. Very considerable reliance is placed on this wheat, both for breeding and for multiplication; in the case of the latter it appears in the notes on multiplications later in this report.

In this group of material the crosses CI 12632 × Kenya 360.H^3 and 360.H^4 are again outstanding. The associated series of double crosses (F_2), in which stem rust and yellow rust resistances are combined, produced a further range of useful material and the cross (Lee Frontana × Kenya 294.M^3) × (CI 12632 × 294.M^3) was specially attractive.

Mention must also be made of barley and oats at this point. Further search for resistance to barley leaf diseases brought 27 varieties from America and Canada; they resisted these diseases but proved highly susceptible to yellow rust and generally unattractive. Clearly a breeding programme to establish better resistance in barley for Kenya would be both lengthy and involved; fortunately it seems hopeful that these leaf diseases can now be controlled by other means and therefore the problem does not look as urgent as was feared previously.

Continued search for stem rust and crown rust resistance in oats has proved most disappointing. A collection of 34 oats from the U.S.A. possessed crown rust resistance but failed badly on stem rust. This is in line with past experience of American varieties from the International Nurseries. Only the diploid oats Saia and *Avena strigosa* showed any promise. Five bulks of crosses from Canada were somewhat more hopeful and selections have been made. Crossings were made between certain locally established varieties and some selected types from the nurseries of earlier years, but only 23 set seed in a total of 73 attempted. This stresses the difficulty of crossing oats under our climatic conditions.

Finally it is opportune to record that a substantial range of the more promising material in the early generation stages was given an extra sowing in the first part of the year as an out-of-season crop in cages. The results were most disappointing and the lack of rust attack led to insufficient selection pressure being applied. This experience stresses the need to use such a method for mechanical generations only, reserving selection work for the natural season when full rust and other selection can take place.

Nurseries

As usual considerable emphasis has again been placed on the International and F.A.O. nurseries. There were 1,156 entries at Njoro, with a duplicate set at Naro Moru, and the special supplementary nursery of wheats for yellow rust

resistance gave a further 248 lines at the high-altitude station at Molo. Barley and oat nurseries were again most disappointing and yielded little of fresh interest. The wheats were heavily attacked by rust at Njoro and the number of new extracts was much lower than hitherto. This is partly due to much of this material having been entered in previous nurseries, but in addition the levels of stem rust attack have left fewer entries worthy of further study. This points to an exhaustion of resistance in ready-made form from such nursery sources, and stresses the need for ever-wider searches and breeding. (This comment must also be linked to the note on the prevalence of the international races 40 and 189—*see* section II under Diseases.)

The special nursery at Molo was less attractive than last season and fewer extracts were taken. Meanwhile the range of selections made in the 1958 nursery have continued to give good yellow rust resistance and a number are being given initial multiplication at Ol Joro Orok.

Initial Multiplications

The range of selections under early multiplication is too extensive to record in any detail. There were 283 plots at Njoro and a further 200 at Ol Joro Orok. Severe selection was necessary on both rust levels and general performance, but there were notable successes. At Njoro the outstanding material was mainly from the International Nurseries of 1957 and 1958, with Idaho 1877 and 1880 specially notable. These derived from the crosses (*T. timopheevi* × CI 12633) × Idead[2] and Lemhi[2], and were entered from Northern Rhodesia after further selection there.

The extracts from the yellow rust nursery of 1958 have already been mentioned and these accounted for the majority of the material at Ol Joro Orok, together with the initial bulks from the barley crosses of 1953. Poor conditions led to disappointing results with most of this material at Ol Joro Orok this year.

District Trials and Observations

A total of 62 wheats and seven barleys were in trial at Njoro or district stations, and within the limitations imposed by altitude each entry appeared at each possible site. Detailed rust records are taken in addition to final yields, so that a composite picture of the value of each variety is built up. With rust so very dominant in the selection of new wheats for release, the simple yield figures are by no means a suitable assessment of potentiality; this is especially true in such a generally good year as 1959 and no detailed comments will be made.

Field Multiplications

The multiplication programme was very much more successful in 1959 than the previous year. Seven varieties were given out-of-season multiplication under irrigation at Njoro at the beginning of the year, and this then meant that there were 12 mother crops during the main season of which three remained on the station. These crops were all of about 5-10 acres, and all but two now go forward to pedigre production on a range of selected farms in 1960. Brief mention may be made of the varieties concerned, as follows:—

For lower altitudes .. No. 43 from South Africa.
Mida-Kenya-Yaqui.
Yaktana 54
(Aquilera-Kenya × Marroqui-Supremo) × Yaqui[2]
374.Q.7.A.4 from the cross Newthatch × 192.Q.2.A.L.

For medium altitudes .. Kentana-Frontana-Mayo.
Veranopolis
Rushmore Surpresa.
Lee Frontana.

For higher altitudes .. 384/5.BJ.6.B.1 a further selection in the "bird series" of wheats released for 1959.

In addition to these varieties at the mother crop stage, there were 32 foundation plots at Njoro and ten at Ol Joro Orok of further varieties coming forward at the $\frac{1}{4}$-$\frac{1}{2}$ acre stage. There was, however, a rather severe culling in this group mainly due to stem rust attack; it included the discard of the three barleys in the programme.

Special mention needs to be made of Frontana-Kenya 58-Newthatch. Last year selection II-50-25 was discarded from field scale multiplications but "unofficial" continuations have been very successful. In the meantime increase of the rival selection II-50-18 continues.

Finally, at the end of the season, a further group of seven varieties was given accelerated multiplication out of season. This time it was not at Njoro, where conditions were too dry, but at the Perkerra Irrigation Scheme near Lake Baringo. The hot conditions there gave a quick but not heavy return in only 13 weeks from planting.

Release of New Varieties

Four new wheats have just been released for 1960, as listed below. Full details have been published in the local Press and will follow in the East African Agricultural Journal. (The previous release, for 1959, was recorded in the article "Release of New Cereals—1959" by H. C. Thorpe and G. E. Dixon in volume XXIV, No. 4, of April, 1959.)

Table 4—Varieties Released for 1960

Variety and Selection	Origin	Altitude Range
Africa x Mayo (3529–1y–4m–3y–1m)	Mexico	6–7,000 ft.
Kentana x Yaqui (2587–8y–6c–1y–3c)	Mexico	6–6,500 ft.
Wisconsin 245 x Supremo* (3638–5h–1h–2h) ..	Mexico	6–7,500 ft.
Mida–McMurachy–Exchange (II–47–26)	Minnesota	7–8,500 ft.

*Wisconsin 245 = (Illinois 1 × Chinese)^2 × *T. timophecvi;* otherwise known as CI 12633.

These new varieties offer an important addition to the range of choice for the lower altitudes, and it is especially welcome that the first three all possess good baking quality.

IV—Breeding—Maize

The grant of special funds under the Colonial Development and Welfare Scheme has enabled the proposed expansion of maize breeding to be launched this year, as mentioned in section I of this report. The existing policy of breeding for both synthetics and hybrids is to be continued but on a bigger scale with a co-ordinated programme to cover all important maize-growing areas, European and African, west of the Rift. The aim is to make a major contribution to the Colony's principal food crop.

Under the new scheme breeding will continue and be increased at Kitale and Njoro, and new breeding programmes will be added at Kakamega and Endebess. Kitale has intermediate conditions for maize and will be the main centre. Njoro serves higher, cooler conditions; Kakamega serves lower, hotter, wetter conditions and Endebess is for areas of higher soil fertility. Exchange of material between centres, with crosses of lines from different centres, will cater for the range of intervening conditions.

The work on maizes for the drier areas continues independently at Machakos and the special programme for maize resistant to *Puccinia polysora* continues at the coast. The notes on work at Machakos also include brief comment on sorghums and millets which are the subsidiary interest there.

Kitale

The routine work of selfing, crossing and trials has continued. The Kitale programme was rather below the increased scale of the past two seasons due to the absence on leave of the Plant Breeder. In all there were 180 selfing plots, 350 crossing plots and 2,000 trial plots. In general the old inbreds produced in the past are very disappointing, whereas the performance of some of the new inbreds from the much more intensive recent effort is showing really good promise. Kitale Synthetic II was multiplied successfully on a plot of five acres at the Grasslands Station.

At Endebess, where a standard breeding cycle was begun in 1957, a whole year's work was lost by a freak severe storm and there will have to be a repeat next year from reserve seed. Preliminary trials and crossing were begun at Kakamega with a view to starting a regular breeding cycle next year.

Breeding for resistance to the leaf diseases—white blight and rust (*P. sorghi*)—has been incorporated into the routine breeding programmes in the past few years and the same is now true for stalk rot. Preliminary results from the first trials of the new Kitale Synthetic II indicate a useful increase in yield and a small reduction of all three diseases.

Njoro

Synthetic II was given initial multiplication on 25 acres and yielded well, but the comparison of Syn. I and Syn. II gave closely similar yields at 26 bags per acre, and a further year of trial is to be undertaken. Meanwhile, intensive seed selection is being carried out for a re-sowing in 1960.

Preliminary figures from the top-cross retrial indicate that some entries may be superior to the existing standard, Syn. I and in the meantime a range of new inbreds (S_1) have been crossed with Syn. II. No further comment will be made at this stage.

Machakos

On the basis of preliminary trials results, the short-term variety Taboran was released in March, 1959, for planting in the hotter, drier parts of Machakos District. The rains were poor, and Taboran appeared to prove its worth by giving a crop, albeit a small one, where the local maize gave virtually nothing. A further release of Taboran was therefore made in October, 1959, and plantings in Kitui District also initiated.

Meanwhile statistical trials on the yield performances of local white and Taboran maizes at different spacings continued at Katumani, and the lower hotter areas (Kikumbulyu, Makueni). From Katumani a clear pattern of results has

emerged: Spacing 3 ft. × 1 ft. (approx. 14,500 plants/acre) is optimum for both maizes to obtain the best yield of good quality grain. With good rains local white outyields Taboran quite considerably. In moderate-poor seasons the yields are equal and under extremely poor conditions Taboran appears to have the advantage. In the lower hotter areas, trials again showed that 14,500 plants/acre (3 ft. × 1 ft. spacing) is optimum. At Kikumbulyu, with 10 in. of rain within the growing season, Taboran outyielded local white, though the trial was somewhat marred by poor stands. At Makueni, with 14 in. of rain within the growing season, Taboran and local white yielded equally well; with 5 in. of rain only, both failed completely, though the Taboran plots did give a very few cobs with grain on. Further trials are necessary to confirm the clear-cut impression given in the field performance of Taboran released to farmers.

A new synthetic maize, "Early Synthetic", derived from local white maize stock has been bred. In its first bulking plot, it silked a week or so earlier than local white, though remaining a week later than Taboran. It gave the satisfactory yield of 12 bags/acre, and seemed relatively disease free.

From the large collection of maizes tested, promising breeding material has emerged, mainly from Taboran crosses with other early and local maizes. These crosses are undergoing selection and inbreeding with a view to forming further early maturing synthetic varieties, with improved yield and disease resistance. A wide range of material is being used, and provides good scope for improving yield, within the range of earliness required. It is less satisfactory as regards white blight resistance and regrettably white blight has emerged as the most important disease occurring on the early maizes.

Mention must also be made here of certain work on sorghums and millets which is complementary to the main interest in maize. In a trial at Katumani, using six varieties of bulrush millet, protected and unprotected from birds, one variety, "Hedgehog", ex-Nyasaland, proved to be bird resistant under these particular conditions. It has therefore been distributed to local farmers to assess its field performance. Though smaller and later than the local millets, its yield (protected) was the same, and its yield (unprotected) outstandingly higher than these.

In a comparison at Katumani of the reliability of yield of sorghum (S.332-high altitude red), and an early maize (Taboran), the Taboran proved the better yielder in both seasons. In both cases the rains were poor, and the sorghum yields were not affected by bird damage.

Coast

The continued multiplication of the first maize resistant to *Puccinia polysora* (Tropical American Rust) was very successful and 100 bags of seed are now being issued elsewhere in Coast Province.* Fortunately, this rust has not been as active lately as it was at first, and it is hoped that this new maize will help stabilize the position. A limited programme only is being continued, aimed at providing an improved synthetic from the first stock. Details of the work from 1953 to 1957 which led to the production of this maize were included in the paper "East African Work on Breeding Maize Resistant to the Tropical American Rust, *Puccinia Polysora*" by H. H. Storey *et al.* in which H. C. Thorpe and G. E. Dixon were co-authors. This appeared in the Empire Journal of Experimental Agriculture, vol. 26, No. 101 of 1958, but mention of the paper was omitted from last year's report.

* From the initial multiplication site in the Shimba Hills.

V—Other Investigations

Wheat Quality

Field trials have continued on this project in collaboration with E.A.A.F.R.O. and Unga Ltd., but results generally have been disappointing. A review of the work from 1955 to 1958 showed the marked effect of seasons on quality data, thus the results have been largely inconclusive. The most important observation so far has been the failure of flour strength values to increase in correlation with increases in protein content. Results for 1959 are awaited with further interest; the better season should have led to a general improvement in quality values.

Soya Beans

At Machakos, assistance has been given in the selection and maintenance of pure varieties of soya beans, pigeon peas and castor beans. Amongst the former are a number of soyas from Nachingwea recorded in previous reports. No further study of these has been made at Njoro, but certain selections and trials were carried out at the Tana River Irrigation Scheme at Galole. In general these soyas are too slow for conditions there. Renewed interest in soyas at Kitale is to be recorded, and the plant breeder there is assisting the district staff accordingly.

Rust Control

This subject has now been taken over by the Senior Plant Pathologist but in the meantime a note on trials carried out this year is recorded in the report of the plant pathologist which follows.

VI—Acknowledgements

The co-operation of the staff of E.A.A.F.R.O. and Unga Ltd., in a number of aspects of the work of this section is again gratefully acknowledged. Special thanks are given to the Rockefeller Foundation and to the International Co-operation Administration of the U.S.A.; to the former for special interest and help (including breeding material from their wheat programmes) and to both for grants for overseas visits recorded in this report.

G. E. DIXON,
Acting Senior Plant Breeder.

ANNUAL REPORT OF THE PLANT PATHOLOGIST (PLANT BREEDING), 1959

General

The principal event of the year was the award of a grant from Colonial Development and Welfare Funds to finance the rust work at Njoro. The full effect of this grant has not yet been felt but it has already made it possible to increase the staff of the plant pathology section and to obtain additional equipment. A considerable sum of money is available for new buildings and a greenhouse with an area of over 2,000 square feet has been ordered. This will be erected during 1960 and fitted with a forced ventilation system for temperature control. Other building projects are planned but final decisions are dependent upon the results of experiments now in progress.

Identification of Races of Wheat Stem Rust

Although the Colonial Development and Welfare Scheme had no direct effect on the volume of rust work in 1959 it was nevertheless possible to increase the number of samples of wheat stem rust (*Puccinia graminis tritici*) submitted for race identity tests from 221 in 1958 to 322 in 1959. The results (Table 1) show that race K16 fell from first to fourth position and that the commonest races were K13 and K18, which were identified in almost equal numbers of tests. K13 was particularly common in the Naro Moru area, where double cropping is practised. Samples collected at the beginning of 1959 from the 1958-59 short rains crop were almost exclusively K13, this being the first time in recent years that such a marked predominance of one race has been recorded. With such a build-up of K13 early in the year, the results of the rust survey on the long rains crop were awaited with special interest. In the event, K13 was still the predominant race at Naro Moru, although K.12, 14, 16 and 18 were also recorded, but elsewhere in the country the proportion of K13 was not exceptionally high and the most damaging race was K18. This was particularly true on the Plant Breeding Station itself where, despite a relatively light rust year over most of the country, a very severe rust epidemic built up and took a heavy toll of breeding material. Seventy-four samples from the station were tested during the year, and, of these, 48 proved to be K18. It is clear from its performance at Njoro that K18 is able to attack a very wide range of wheats and must be regarded as a serious menace for the future. Another race which is potentially very damaging is K19 as will be explained later, but although this race was fairly widespread in 1959 it did not multiply as had been expected and was in fact less common than in the previous year. Nevertheless, its future performance will need to be watched very carefully. K12, which increased markedly in 1958, continued at roughly the same level in 1959.

TABLE 1—PERCENTAGE FREQUENCY OF STEM RUST RACES DURING 1957, 1958 AND 1959

KENYA RACE	NUMBER OF ISOLATIONS (PERCENTAGE OF TOTAL)		
	1957	1958	1959
K11	2	—	—
K12	7	18	17
K13	14	10	23
K14	5	16	10
K15	—	—	—
K16	34	20	12
K17	13	6	4
K18	14	16	24
K19	11	13	6
Others	—	—	4

NOTE.—In Table 1, two or more isolations of the same race from a set of experimental plots at a single site are treated as one record only. All isolations from farm crops are considered separately.

Identification of races on the international system was again hampered by shortage of the appropriate differential varieties. It did, however, prove possible to test the standard "K" races on the international system, with the results shown in Table 2.

TABLE 2—IDENTITY OF KENYA STEM RUST RACES ON THE INTERNATIONAL SYSTEM

Kenya Race	International Race
K12	21
K13	24–42*
K14	143
K16	40
K17	40
K18	40 —
K19	189 —

* K13 is apparently intermediate between international races 24 and 42 which are mainly differentiated on the variety Khapli. It may be that more than one form exists.

The first three results confirm those of earlier workers but races K16 to K19 have not previously been tested on the international system. It is interesting that K16, 17 and 18 are all equivalent to race 40 and may be regarded as sub-races of this race. International race 189 is the most virulent known, attacking all the standard differential varieties; its presence in Kenya is therefore of the greatest importance. In addition to tests on "established" races, use of the international differentials indicated the presence of six more races. These results have yet to be confirmed but correspond in general with what is known in neighbouring countries. The work on stem rust was reviewed in the August edition of "The Kenya Farmer".

International Co-operation in Rust Work

Great stress is now placed on the importance of international co-operation and exchange of information on cereal rusts. This aspect developed well during the year and it is hoped that firm foundations have been laid for further progress in the future. In particular a member of the plant breeding staff and I visited Turkey and Ethiopia during the year. In Turkey we attended the sixth Near East Wheat and Barley Breeders Conference which was held in Ankara in June under the auspices of the Food and Agriculture Organization. The conference provided many valuable contacts with rust pathologists throughout the Near East and gave a clearer picture of progress on rust work in the region than is obtainable from published work. The visit to Ethiopia was made in early December at the invitation of the United States Operation Mission. Tours were made of the wheat growing areas and it was possible to advise on the setting up of rust testing facilities. The establishment of this work in Ethiopia will provide a valuable link in the chain of centres where information on rust races is available. Ethiopia is of particular significance to Kenya in that any races present there will almost certainly reach Kenya, by means of spores blown down on the north-east monsoon. The discovery during the year that wheat grown at Marsabit in the Northern Frontier Province is commonly attacked by rust makes this still more likely. Identity tests on rust collections from Marsabit have yielded only races common to both countries.

A comparison of the rust race pattern in Kenya with that of other countries of Africa and the Near East shows very marked similarities, with some races occurring in a large number of countries. This work will be reported more fully elsewhere.

Other Rusts

Work on race identification of yellow rust (*Puccinia glumarum*) was hampered by the lack of greenhouse accommodation with suitable temperature control. Participation in the European Yellow Rust trials made it possible to send samples to Germany for testing, however, and provides a very valuable interim measure until testing facilities can be set up at Njoro. A small controlled climate cabinet was built during the year and has been valuable in pilot experiments.

The differential varieties for stem rust and crown rust of oats were received too late in the season for extensive testing, but a start was made on the identification of the races of oat stem rust.

Spore Trapping

Trapping and counting of air-borne spores was started during the year using a Hirst Automatic Volumetric Spore Trap. The instrument is running continuously on the Plant Breeding Station, together with a recording anemometer, recording rain gauge and thermohygrograph. It is hoped that this work will give valuable information on the conditions governing rust spore movements. Portable spore traps have been obtained for other aspects of this investigation.

Chemical Control of Cereal Rusts

Trials on the chemical control of cereal rusts and barley leaf diseases were organized by the Department of Agriculture in co-operation with commercial firms during the 1958-59 short rains season at Naro Moru. The fungicide "Zineb" was applied to wheat by means of ground and air sprays and to barley as ground sprays only. The trials were reported in "The Kenya Farmer" of

September, 1959, with the conclusion that control of the diseases concerned by means of chemical sprays was not an economic proposition with the fungicides now available.

Cereal Diseases and Advisory Work

The general level of cereal diseases was much lower in 1959 than in the previous year, as the result of a much drier season.

Stem rust of wheat was rarely very damaging and although isolated pockets of rust built up in individual fields there were also many instances of highly susceptible varieties escaping rust attacks completely. Stem rust levels at the Plant Breeding Station itself were, however, exceptionally high, as reported above. Brown leaf rust (*P. recondita*) did little damage and the amount of stripe rust (*P. glumarum*) was also small, but the ear rust phase of the disease was common in the higher areas. This was attributed to low night temperatures, and led to considerable shrivelling of the affected grain.

Damage from "Take-all" (*Ophiobolus graminis*) was also lower than usual, but the wheat variety 1066 was often observed to be heavily attacked by both this disease and by yellow ear rust especially at the highest altitudes of around 9,000 ft.

The leaf diseases of barley caused by *Helminthosporium teres, H. sativum* and *Rhynchosporium secalis* showed a spectacular fall from the previous year.

Approximately 50 specimens were received for general diagnosis and advice.

E. J. GUTHRIE,
Plant Pathologist.

ANNUAL REPORT OF THE COFFEE RESEARCH STATION, RUIRU, 1959

The weather in most of the coffee areas during 1959 was closer to the normal pattern than for several years. Unseasonable rain during the dry season prior to the long rains occurred only in the west of Rift areas. The long rains were generally late and were succeeded everywhere by prolonged dry weather. In the Trans Nzoia and East of Rift districts the five months up to the end of October were especially dry. Consequently the quality of the early crop, which was of an unusually high proportion, was adversely affected, although earlier ripening undoubtedly alleviated crop strain on the trees. Except in Nyanza the relative absence of infective periods before the long rains was expected to arrest the recurring epidemic of Leaf Rust which has been so prominent a feature of the past four years. In the event, however, the lower zones east of the Rift suffered from severe defoliation due to the disease before the onset of the short rains.

Whilst Coffee Berry Disease was more widespread in Nyanza the dry weather favoured a decline of infection elsewhere. During the year the disease advanced in Central Province and became established in the most southerly locations of Meru District.

RAINFALL AT THE DEPARTMENT'S COFFEE STATIONS DURING 1959

	A	B	C	D	E	F	G	H
January ..	1·33	0·71	1·55	0·24	2·82	1·16	No record	No record
February ..	0·21	0·61	1·07	2·63	4·18	2·11	,,	5·17
March	3·43	5·01	3·33	4·03	18·10	4·42	,,	8·39
April	3·98	3·38	4·08	5·10	10·87	7·15	,,	9·35
May	8·69	3·44	9·04	3·55	4·97	5·27	2·90	7·28
June	0·07	0·00	0·00	1·95	4·40	0·08	0·00	1·41
July	1·26	1·08	0·17	3·32	1·02	1·66	0·42	2·89
August ..	0·68	1·81	0·36	3·12	6·07	1·19	0·42	4·50
September ..	0·70	0·49	0·04	2·18	8·86	1·24	1·97	2·28
October ..	0·48	1·46	0·52	4·65	5·11	1·06	1·00	3·21
November ..	10·01	11·37	8·04	3·56	5·90	11·58	17·36	7·07
December ..	2·86	2·22	2·75	0·29	2·19	2·87	7·11	3·19
Total	33·70	31·58	30·95	34·62	74·49	39·79	(31·18)	(54·74)
No. of Days Total ..	120	110	88	135	182	132	(72)	(123)
Means and number of years	38·98 15	36·95 34	37·19 20	45·57 26				

A = Coffee Research Station, Ruiru.
B = Scott Agricultural Laboratories, Kabete.
C = North Kitito Estate, Makuyu.
D = Kitale Experimental Station.
E = Experimental Farm, Kisii (Coffee Research Substation from 10.12.59).
F = Upper Kiambu Coffee Research Substation.
G = Mariene Coffee Research Substation, Meru.
H = Koru Coffee Research Substation.

The Coffee Berry Disease Research Unit has continued its study of the epidemiology and control of the disease and, early in the year, was able to undertake a similar programme of investigation into Leaf Rust control. Detailed advice for control of both diseases, based upon field evidence, was formulated towards the end of the year.

In the field of processing research studies of the problem of artificial drying were brought to a successful conclusion and comprehensive advice was issued to the industry prior to the departure in April of Mr. J. F. McCloy, Senior Scientific Officer, E.A.I.R.O. Whilst subsidiary aspects of the problem require further investigation the major findings have shown that artificial drying techniques can be employed whereby no loss of quality is incurred, provided that the coffee is exposed to the bleaching effect of sunlight for a specified period during the process. No economic artificial substitute for the bleaching effect of the blue rays of sunlight is in sight, however; in its absence methods of drying as an emergency measure have been evolved to reduce degradation of quality to a minimum. Since April the programme was continued by Mr. C. L. Gough, Assistant Agricultural Officer, with particular reference to time and temperature studies of ventilated bins and, in collaboration with Mr. A. E. Wootten, Chemist of E.A.I.R.O., a new attack was launched on the problem of onion flavour.

The Entomologist's attention was directed mainly to investigating three of the major pests currently causing concern in the industry. Some useful progress was made in studies of the bionomics and control of Leaf Miner, Tip Borer and Antestia, using an approach which is designed to reveal ways of achieving lasting control without frequent resort to chemical measures, which are liable to upset the balance of control of other pests.

Mr. Robinson's research in Agricultural Chemistry has been concentrated on soil fertility problems, in particular the influence of Napier grass mulch, manurial and cultural treatments upon soil fertility. With the appointment of a trained technologist the research programme of foliar analysis by spectroscopy was begun towards the end of the year.

Of the many and varied cultural problems under investigation experiments concerning grass mulch, cattle manure and nitrogen fertilizers have been prominent for the past ten years. At the end of the 1958/59 season an appropriate point was reached for assessing the results obtained: a summary of the investigations and their conclusions was written in the form of a scientific paper and articles containing practical recommendations were published in *Kenya Coffee*.

After his arrival in July the Pathologist devoted most of his time to the condition known as Stem-pitting. A Colony-wide survey was undertaken in the last quarter of the year with the object of clarifying the circumstances surrounding its incidence and severity. As a result of the survey it was possible to formulate a research programme with precise objectives.

The study of coffee physiology was separated from pathology upon the apointment of Dr. T. M. Wormer in April. Of the many major problems those concerned with water relations and carbohydrates in the tree have particular prominence. After preliminary studies of technique and method had been concluded a comprehensive programme was planned and initiated, incorporating these subjects as major lines of research.

Results accruing from the programme of variety trials throughout the coffee areas are now of considerable value in guiding the expansion of coffee acreage on plantations and peasant holdings, especially in relation to disease and drought resistance: the year under review was marked by an accelerated flow of such information.

A comprehensive record of all investigations undertaken during the year will be included in the separate report covering the 1959/60 crop season. This report is scheduled for publication in July, 1960. Copies will be obtainable from the Coffee Research Station, Ruiru, and from the Coffee Board of Kenya, Etco House, Nairobi.

P. A. JONES,
Senior Research Officer.

ANNUAL REPORT OF THE ENTOMOLOGIST (COFFEE SERVICES), 1959

The pattern of Leaf Miner (*Leucoptera meyricki* Ghes. and *L. caffeina* Washb.) was the same as in previous years. Outbreaks became widespread and severe after the end of the long rains but had generally declined by mid-December, except in Upper Kiambu. Following the discovery that the common organophosphorous insecticides are ovicidal revised recommendations were made for Leaf Miner control. Parathion, Methyl Parathion and Diazinon were the chemicals most used by planters. Experiments at the Pyrethrum Board of Kenya's laboratories showed that Pyrethrum sprays are ovicidal at concentrations as low as 0.001 per cent Pyrethrins. A regular supply of mined leaves was arranged from six stations east of the Rift Valley, including the Taita Hills and three stations west of the Rift Valley. Eighteen species of parasitic Hymenoptera have been recovered from these samples. The commonest parasite has proved to be an undescribed species of *Cirrospilus*. One parasite species is common in Kisii but has not been found in any of a large number of East Rift samples. A number of parasite species recorded in Tanganyika have not yet come to light. One surprising observation that emerged from this Leaf Miner parasite survey is that the shade-loving *L. caffeina* is absent, or very rare in the West Rift, despite the fact that much of the coffee is shaded. Feeding observations have shown that if *L. meyricki* moths are given Mealybug honeydew their egg production is approximately double those fed on honey. Since coffee flowers for short periods only and plantations are usually free of all but grass weeds, honeydew is presumably the natural food of Leaf Miner moths.

Antestia (*Antestiopsis lineaticollis* Stal.) attacks were not outstandingly severe during 1959. This appeared to be partly due to extensive spraying against Leaf Miner and partly to a high percentage of parasitism of Antestia nymphs by the Braconid *Aridelus coffeae* (Brues). Malathion and Methyl Parathion were the chemicals most commonly used for controlling Antestia. A two-phase method of Antestia control was devised for African areas and small plantations. Trees are sprayed with 0.006 per cent Pyrethrins and their stumps are dusted with 5 per cent D.D.T. The spray gives a high initial knockdown and the dust ensures that those bugs which recover from their initial paralysis are killed when attempting to climb back on the tree. This work, which was done in collaboration with the Pyrethrum Board of Kenya, is being written up for publication. A Tachinid parasite, probably *Epineura rubens* Vill., was bred from adult *Antestiopsis* collected in the Kisii Highlands. Adults kept in cages oviposited freely on the Ruiru variety of *A. lineaticollis* and a new generation of adult flies had bred through by the end of the year.

Using flower buds and small green berries as food a successful technique for the laboratory rearing of the Tip Borer *Eucosma nereidopa* Meyr. was developed. The larva changed its position two to three times during its development; this corresponds with field observations on its habits. At laboratory temperatures the following approximate development periods were recorded: egg, 8 days; larva, 36 days; pupa, 21 days; pre-oviposition, 5 days. This makes a total of 70 days. Moth counts at Upper Kiambu suggest that the corresponding period in the field is nearly 120 days. Spraying shade tree trunks with 2 per cent D.D.T. caused large reductions in the moth population. It is not yet clear whether this spray complemented with cultural measures will give sufficient control or whether there will have to be other sprays.

It was reported from Tanganyika that the Dieldrin treatment for White Borer *Anthores leuconotus* Pasc. control is effective for more than two years if correctly applied. The third phase of the spray campaign planned for April, 1959, was

accordingly cancelled. Surveys took place in April and October to find out the effect of the first two sprays. In April only eight out of 2,500 trees on ten estates were still harbouring active larvae; in October no active larvae were found in 2,500 trees. Coffee too young to be treated during the 1958 campaigns was badly attacked and had to be treated.

There was a severe, but fortunately fairly localized, outbreak of the Yellow Headed Borer *Dirphya nigricornis* (Ol.) in the Thika District. Several new observations on the life history of this pest were made. 0.2 per cent Dieldrin in kerosene injected into the tunnels proved a useful substitute for the fumigant EDCT and was widely used as a control measure.

Lace Bug *Habrochila ghesquierei* Schout. extended its range to the Nyeri and Embu districts during the year. Though there were a number of severe outbreaks in Kiambu, Thika and Ruiru, on the whole it caused less trouble than in previous years.

During the year small-scale investigations were also undertaken on the control of Coffee Thrips (*Diarthrothrips coffeae* Williams), Waxy Scale (*Ceroplastes brevicauda* Hall), Brown Scale (*Saissetia coffeae* (Walk.)) and other minor pests.

1959 was the second full year in which an Entomological Field Officer was available on demand to give advice to planters. He made 201 advisory visits compared with 104 in 1958. Leaf Miner and Lace Bug were the subjects on which advice was most commonly sought.

Much assistance was received from the Commonwealth Institute of Entomology in the identification of insects and this is gratefully acknowledged. Mr. G. de Lotto identified numerous scale insects and mealybugs. As usual, many growers permitted experiments to be done on various pests on their estates during the year. Their co-operation is essential and much appreciated.

T. J. CROWE,
Entomologist (Coffee Services).

ANNUAL REPORT OF THE AGRICULTURAL OFFICER (INVESTIGATIONS), 1959

Mulch Trial

The new pruning cycle came into full bearing on this trial in 1959, and the average yield for the trial was just under three-quarters of a ton of clean coffee per acre.

The mulch treatments applied before the onset of the long rains increased the yield of clean coffee by as much as 4 cwt. per acre, while the July treatment raised the yield by about 2½ cwt. per acre.

TABLE (*a*)—MULCH TRIAL—YIELD SUMMARY, 1959, CWTS. CLEAN COFFEE PER ACRE

	No Nitrogen	Urea 46 lb. Nitrogen Acre	Sodium Nitrate 46 lb. Nitrogen/ Acre	Ammonium Sulphate Nitrate 46 lb. Nitrogen/ Acre	Means for Mulch treat-ments
No mulch	11·58	12·85	13·14	11·69	12·31
All inter-rows pre-rains —March	15·60	16·74	16·39	17·48	16·55
Alternate inter-rows pre-rains—March ..	15·68	14·61	15·84	15·15	15·32
All inter-rows post-rains —July	14·05	14·59	16·25	14·20	14·77
Means for Fertilizer Treatments	14·23	14·70	15·40	14·63	14·74

Least Significant Difference—

	Within the Table	Between Marginal Means
p=0·05..	1·88	0·94
p=0·01..	2·54	1·27
Coefficient of Variation	8·84%	

In 1959 the treatment which consisted since 1954 of applying 46 lb. of nitrogen per acre half in the ammonium and half in the nitrate form was modified by using as the fertilizer ammonium sulphate nitrate (A.S.N.) to supply the same rate of nitrogen per acre. Although the overall response to this treatment was not significant, where A.S.N. was put on to the bare soil in April between an all inter-row mulch, which had been laid in March, there was an increase in yield which just attained statistical significance. As shown by the mean yields at the bottom of Table (*a*), there was a significant overall response to the sodium nitrate fertilizer. In this case the main yield increases were recorded from unmulched plots or those which were not mulched until three months after the fertilizer had been applied.

TABLE (*b*)—THE EFFECT OF MAGNESIUM FERTILIZER ON THE RESPONSE TO MULCH, 1957-1959

(*Mean annual yield in cwts. of clean coffee per acre*)

	Without Magnesium	With Magnesium	Effect
No mulch	7·76	7·88	+0·12
All inter-rows pre-Rains—March	11·01	11·98	+0·97
Alternate inter-rows pre-Rains—March	8·75	9·18	+0·43
All inter-rows post-Rains—July ..	12·74	11·43	−1·31
Means	10·07	10·12	+0·05

In 1956 the plots in one replicate of this trial were split to allow, as an additional treatment, the testing of a magnesium fertilizer. Yields are now available for the three seasons (1957-1959), but no significant differences in yield can be detected between the treatments with or without magnesium.

TABLE (*c*)—THE EFFECT OF MULCH ON BEAN SIZE 1951-1958

(*Mean annual yields of coffee in cwts. clean coffee per acre*)

Grade A Screen = 6.75 mm.

	Yield of Grade "A" Coffee	Yield Increase %	Yield of less than Grade "A"	Total Yield	Yield Increase %
No mulch	2·52	—	4·08	6·60	—
All inter-rows pre-Rains—March	4·34	+72%	5·26	9·60	+45%
Alternate inter-rows pre-Rains—March ..	3·34	+33%	5·41	8·75	+33%
All inter-rows post-Rains July	4·58	+82%	5·76	10·34	+57%
Least Significant Difference—					
p=0·05	0·91	36%		1·71	26%
p=0·01	1·23	49%		2·30	35%
p=0·001	1·63	65%		3·06	46%
Co-efficient of Variation	11·41%			8·80%	

At each picking for each season since 1951, one-tenth samples have been taken from the yield of each plot of the trial. At the end of each picking season the aggregate samples which are formed by bulking all the samples for each plot have been hulled and graded. From this procedure it has been possible to obtain the information shown in Table (*c*), which shows the effect that the various mulch treatments have had on the yield of Grade A coffee. The mulch placed between alternate rows in March each year has increased the general mean yield for the eight years by 33 per cent and the quantity of Grade A coffee has risen by the same proportion. Where the mulch has been laid between all rows of coffee in

March or July, not only has the mean overall annual yield been increased by between 45 per cent and 57 per cent but furthermore the proportion of Grade A coffee has risen to a greater extent so that these treatments have produced between 72 per cent and 82 per cent more large sized beans than have been picked from the unmulched plots.

On many occasions samples of coffee from the various treatments in this trial have been submitted to the Liquorer of the Coffee Marketing Board of Kenya. From his detailed reports on the appearance of the coffee, raw or roasted, and his comments on the coffee liquors, no consistent effects of cultural treatments on the final classification of the coffee have been detectable.

From this work on coffee quality it is concluded that all three mulching treatments have raised substantially the yields of all sizes of coffee bean and that the all inter-row mulch treatments have increased the proportion of Grade A coffee. There is no evidence that these increases in yield have been associated with any reduction in quality as represented by descriptions of raw or roasted coffee or by reports on the coffee liquor.

Kentmere Variety Trials

In 1954 two variety trials were planted on Kentmere Estate in Upper Kiambu to test a number of selections which were of interest to coffee growers at high altitudes and those in areas where Coffee Berry Disease is likely to be a problem.

TABLE (*a*)—KENTMERE VARIETY TRIALS, 1958 AND 1959

(*Yields in cwts. of clean coffee per acre*)

Variety	1958			1959		
	Rank	Yield	Brown Blight Index	Rank	Yield	Brown Blight Index
TRIAL I						
Blue Mountain K.7 ..	2	5·90	13·84	1	4·98	5·00
Blue Mountain P.12 ..	8	4·70	15·38	2	4·88	4·38
Blue Mountain S.10 ..	10	4·28	15·00	3	4·88	2·50
Blue Mountain J.7 ..	11	4·17	14·23	4	4·79	3·75
Blue Mountain N.1 ..	9	4·41	16·15	5	4·66	5·31
Blue Mountain I.11 ..	4	5·36	13·07	6	4·23	2·81
Blue Mountain Q.6 ..	7	4·75	16·15	7	4·16	3·44
Geisha 10	16	3·58	12·30	8	4·14	13·44
Kenya Selected	13	3·95	22·30	9	4·09	5·63
Blue Mountain L.3 ..	5	4·83	18·07	10	4·09	3·13
Blue Mountain P.13 ..	1	6·11	16·53	11	4·02	4·38
Blue Mountain S.5 ..	12	3·96	15·00	12	3·95	2·19
Blue Mountain W.12 ..	14	3·68	15·38	13	3·59	2·81
Blue Mountain V.13 ..	15	3·62	14·61	14	3·41	4·38
Blue Mountain P.8 ..	6	4·75	13·84	15	3·32	4·06
Blue Mountain R.12 ..	3	5·54	17·30	16	3·02	2·50
Mean		4·60	15·57		4·14	4·36
Coefficient of Variation ..		18·93%			21·05%	
Least Significant Difference p=0·05		1·11			1·11	
TRIAL II						
S.L.28	2	9·54	32·30	1	8·72	9·06
S.L.34	1	9·54	35·76	2	8·55	13·44
Geisha 1	8	7·93	20·76	3	8·41	11·88
Kents	3	9·27	37·30	4	5·70	17·81
Ke.20	7	8·10	24·22	5	3·51	4·06
Blue Mountain X6 ..	9	7·20	21·15	6	3·23	2·50
Blue Mountain N4 ..	5	8·29	13·07	7	2·99	2·81
Blue Mountain I5 ..	4	8·39	16·92	8	2·86	3·13
Blue Mountain U4 ..	6	8·14	19·99	9	1·69	3·13
Mean		8·49	24·61		5·07	7·54
Coefficient of Variation ..		11·46	—		17·05	—
Least Significant Difference						
p=0·05		1·46	—		1·30	—
p=0·01		2·10	—		1·79	—
p=0·001		—	—		2·46	—

Yields recorded for the first two crops from the 25 selections represented in these trials are summarized in Table (*a*).

In Trial I yields have been low and variations between selections slight, but the results from Trial II indicate substantial varietal differences. In both years

S.L.28, S.L.34 and Geisha I have yielded between 8 and 9½ cwt. of clean coffee per acre, but the crop from the Blue Mountain selections have falled from 8 to 2¾ cwt. per acre.

The Brown Blight index represents an average percentage incidence of Brown Blight at each picking. This index shows that the 1958 intensity of attack was 3½ times that recorded in 1959 and that Kents, S.L.34, S.L.28 and Kenya Selected are particularly susceptible; Ke.20 and Geisha I and Geisha 10 are in an intermediate group; the Blue Mountain selections are all similar in their resistance to Brown Blight.

J. A. N. WALLIS,
Agricultural Research Officer.

ANNUAL REPORT OF THE AGRICULTURAL OFFICER (RESEARCH), COFFEE LIAISON (AFRICAN DISTRICTS), 1959

Coffee Variety Trials in African Areas

Throughout Nyanza Province below 5,600 ft. the ability of coffee to resist attack by Leaf Rust (*Hemileia vastatrix*) is of paramount importance. A similar situation also exists in Meru District (Central Province) below about 4,500 ft. and in the Taita Hills (Coast Province).

During 1956 a series of Rust Exposure trials was planted in various Kenya coffee areas. In the African areas trials were established at Wundanyi (Taita District), at Chugu (Meru District), at Siriba (Central Nyanza District) and at Kamagambo (South Nyanza District). Race I of Leaf Rust is now known to occur in all the districts where the trials are situated. The varieties originally planted included K.7, KP.532, S.288, S.333 and S.795. In 1959 the trials were extended to accommodate five resistant selections of the B.A. series obtained from the Coffee Research Station, Balehonnur, Mysore.

The only varieties planted in these trials in 1956 which have shown immunity to Race I and II of Leaf Rust are the Indian varieties S.288, S.333 and S.795. These varieties produced their first small crop during 1959 and continued to exhibit about 75 per cent immunity to Leaf Rust in all the trials. If the liquoring quality and yields produced are satisfactory, they should prove invaluable in the Race I endemic areas of the Nyanza and Central Province.

Although there is abundant evidence to indicate that K.7 possesses some field resistance to Race I of Leaf Rust, this variety can now be recommended with complete confidence only where Race I is known not to be endemic. In areas where only Race II occurs the variety K.7 will continue to be recommended.

A particularly severe outbreak of Leaf Rust occurred in the Elgon Nyanza District during 1959. Trials of the variety K.7 were sometimes severely debilitated by overbearing, as a direct consequence of heavy leaf fall caused by Leaf Rust. Arrangements have been completed for the planting of a Rust Exposure trial in this District during April, 1960.

The mapping of the distribution of Rust Races was continued by the Plant Pathology Section at the Coffee Research Station during 1959. Race I is now known to occur extensively in the following districts: Elgon Nyanza, North Nyanza, South Nyanza, Meru and Taita. Every effort was made to isolate the new Race VII recorded by Dr. d'Oliveira of the Coffee Rust Research Centre, Portugal, from leaves supplied to him from Yabe, South Nyanza District, in 1958, but without success.

B. HANGER,
Agricultural Officer (Research).

ANNUAL REPORT OF THE PLANT PATHOLOGIST, COFFEE SERVICES, 1959

Leaf Rust

There was a considerable number of infective periods during the first four months of the year which allowed a steady build-up of Rust infection, particularly where the January spray was omitted.

Race I is now confirmed in the following districts: North Nyanza, South Nyanza, Elgon Nyanza, Meru, Teita and Ithanga Hills. Numerous Rust collections from South Nyanza and other areas have again failed to reveal any further isolates of Race VII. The sole isolation of this Race in 1957 has therefore not been confirmed from its original site or elsewhere.

Fungicide Trials Against Leaf Rust

Two fungicide trials are in progress comparing the relative efficiency of ten different fungicides. Burgundy and Perenox have achieved the most satisfactory control of Rust based on a Rust count method of assessment but no yield results are yet available from these trials. Copper dusting has not proved very effective under the conditions of the trial and probably needs to be applied more frequently than the recommended intervals for the standard sprays.

In a trial to compare the times of application of sprays, spraying at three-monthly intervals based on the May anti-leaf fall spray has given almost equivalent results to the usually recommended programme.

Copper Sulphate

In order to determine the possible toxic effects of copper sulphate sprays, concentrations of copper, as copper sulphate, up to 10,000 ppm., were sprayed on to young coffee plants. At concentrations of 5,000 ppm. and above numerous brown necrotic spots have appeared on both surfaces of the leaf. Below this concentration the effects have not been very marked so far.

Crinkle Leaf

A condition causing leaf deformation known as "Crinkle Leaf" has been widely observed and been particularly severe in the nursery at the Coffee Research Station, Ruiru. A preliminary investigation of this condition was carried out and while numerous fungi can be isolated from such leaves none of them are considered to be primary parasites. Studies of the condition in association with the Plant Physiologist indicate the symptoms to be different from those of "Hot and Cold" disease and it is commonly observed that it is either absent or much less severe on trees under shade.

Stem-pitting

A survey of this condition was conducted in most of the coffee-growing areas of Kenya. The widespread occurrence of Stem-pitting was confirmed and three main types of symptoms were recognized. These were: gum pockets and small pits in the wood cylinder with corresponding pegs in the phloem; the typical furrowing and stem deformation; and thirdly, furrowing associated particularly with the capping zone. Anatomical investigations have shown that the symptoms often start in very young seedlings and therefore cultural factors affecting the plant after planting out in the field are unlikely to be responsible for initiating the condition. In view of the severity of the symptoms in certain areas it was thought that the possible future seriousness of the condition should be assessed.

I. D. FIRMAN,
Plant Pathologist.

ANNUAL REPORT OF THE PLANT PHYSIOLOGIST, COFFEE SERVICES, 1959

Several new investigations were undertaken, but as the reorganization of the Physiology and Phytopathology Section has been carried out recently, only preliminary results are available.

Carbohydrate Studies

In conjunction with the Chemistry Laboratory, an experiment has been laid down to study levels of starch and mineral elements in various parts of the tree throughout the year. The experiment comprises three crop levels: no crop, "normal" cropping, and overbearing. Mineral elements in the leaves and starch in roots, leaves, branches and crop are being analysed at monthly intervals and the values obtained related to their age and their positions on the tree.

Preliminary investigations were directed towards the development of visual methods of starch measurement. In branches of multiple-stem coffee, most of the starch is concentrated in the parenchymatous pith. After staining with iodine, the intensity of the developing blue colour can be estimated with great accuracy with the aid of a microscope with a lower power magnification and a network graticule. Comparison with chemical analysis showed an excellent correlation between the two methods up to a level of 2.5 per cent of starch on dry matter. At this stage the tissue of the pith is dark blue and this intensity of colour does not change even when the amount of starch increases up to 6 per cent.

Wassink's method (*Acta Botanica Neerlandia,* 2 (3), 1953, 327-348) of scoring starch in leaves of Helianthus by extracting the chlorophyll and staining the starch with iodine was investigated for coffee. The technique uses a constant light source, the amount of intercepted light being related to the quantity of starch present in the leaf. In coffee leaves, however, starch is not broken down and removed from the leaves at night but is built up till it reaches very high levels. As a result, staining with iodine often produces such a dark coloration of the leaves that all light is intercepted and no quantitative measurement is possible.

Water Relations

Weatherley's method (*New Phytologist,* 49, 1950, 81-97, *ibid.* 50, 1951, 36-51) of measuring water deficit of leaves was adapted to coffee. This method consists of punching discs out of leaves and measuring their fresh weight, their weight after floating on water and their dry weight. Details of the procedure vary with the plant under study. In coffee, the normal water deficit is replenished after approximately 35 minutes' floating time and no appreciable loss of dry matter occurs. When the discs are floated upside down water uptake after 35 minutes is only slow but when floated in the normal position more and more water is taken up until the discs become waterlogged.

In soils not too close to the permanent wilting point, the water deficit of the leaves increases slightly in the course of the day. It is only when the permanent wilting point is nearly reached that important deficits arise.

Molisch's infiltration method (*Zeitschr. f. Bot.,* 4, 1912, 106-122) for following stomatal behaviour was tested using mixtures of isopropyl-alcohol and water. It was found to be entirely satisfactory and will be used on an extensive scale, especially in view of its value for giving information on the water relations of the tree. A complication is, however, that according to Nutman's findings (*Ann. Bot. N.S.*I (4), 1937, 681-693), light intensity has an important influence in determining stomatal behaviour. This will be studied in more detail.

Leaf Fall

The presence of leaves on thick stems of several years of age shows that, potentially, leaves can live for a long time. As premature leaf fall is one of the reasons for overbearing and poor health of the tree, reduction of leaf fall is of major importance. No abscission layer consisting of small-sized cells is found in coffee but leaf fall occurs by dissolving of the middle lamella of an otherwise indistinguishable layer of cells in the petiole.

Many chemicals have a potential value for delaying leaf fall. In order to reduce their number to practical limits for field testing a suitable method of laboratory screening has been sought. A method is under trial which consists of keeping petioles and 2 cm. of leaf blade of the treated leaves in darkness till abscission takes place: the first results with this method are promising.

Root Systems

There are sound theoretical grounds for the contention that grass mulching, when practised for some years, will modify the root distribution of the tree within the top 2 ft. of the profile. Trees in the Mulch and Soil Regeneration Trial at the Coffee Research Station have been mulched annually on one or both sides consistently every year for ten years.

When root systems of sample trees were exposed by washing no differences were found which could be ascribed to the presence or absence of mulch over a prolonged period. This result is certainly unexpected and may be due to various circumstances. Further study is required to clarify this problem.

T. M. WORMER,
Plant Physiologist.

ANNUAL REPORT OF THE AGRICULTURAL CHEMIST, COFFEE SERVICES, 1959

The effect of Napier grass on coffee soil fertility was evaluated using a micro-pot test method (Chenery's variation of the Webb technique). Following field trials in which substantial coffee yield increases have been found in response to mulching with Napier grass, the practice is now a part of the routine cultural programme on most coffee estates in the drier districts. Research has demonstrated that increased rainfall acceptance and conservation of moisture, together with improved soil structure, result from mulching; but soil fertility improvement has been accepted hitherto without a great deal of work on the assessment of this factor.

Three bulk topsoil samples were collected from each of the no-mulch and plus-mulch plots, at depths of 0-4 in., 0-8 in. and 0-12 in.. The plots were those in the Mulching and Soil Regeneration trial on the Coffee Research Station; the plus-mulch treated plots had received an annual application of Napier grass over a period of ten years. The growth values, i.e. dry matter weight of the aerial portion of tomato seedlings expressed as a per cent of the + All nutrient treatment, are summarized in Table 1. The experimental layout comprised three replications of ten nutrient test treatments plus and minus mulched soil at three sample depths.

TABLE 1

SUMMARY OF TOMATO SEEDLING GROWTH IN A COFFEE SOIL ± MULCH (OVER THREE SOIL SAMPLE DEPTHS)

Pot Treatments	+Mulch soil	−Mulch Soil		±Mulch soils
		(1)‡	(2)	
+All nutrients	100% (9)	100% (9)	28% (9)	100% (18)
−All nutrients	60%	42%	12%	56%
−Nitrogen	64%	79%	22%	67%
—Phosphorus	69%	29%	8%	60%
−Potassium	65%	70%	20%	66%
−Sulphur	64%	86%	24%	67%
−Magnesium	80%	84%	24%	81%
−Calcium	74%	88%	25%	77%
−Trace Elements	67%	64%	18%	67%
−Chloride	77%	88%	25%	79%
Comparative overall Means ±Mulch (% of + Mulch value)	100% (90)	29%		—

NOTES—

(9) etc. is number of figures in the mean.

L.S.D's.: 2 means of 9=11%*; 15%** (per cent of + M, + all treatments).
2 means of 18=12%; 16%; 21%*** (per cent of +M, + all treatments).
2 means of 90=9%*** (per cent of + M mean overall pot treatments).

‡Growth expressed as a percentage of the −Mulch, +all treatment.

In respect of tomato seedlings' growth it is obvious that the mulching treatment has very greatly increased the productivity of the soil. This increase will of course include the effect on soil structure as well as plant nutrient content and such structure differences were visible in the pots throughout the test. It also appears that the mulched soil is not specifically deficient in any one of the nutrients which were tested; the unmulched soil shows a severe deficiency of phosphorus and a deficiency of nitrogen (— Mulch soil data). Considering the values for the unmulched soil expressed as a percent of the — Mulch + All treatment (— Mulch soil data) it is apparent that nitrogen and phosphorus are the plant nutrients in the shortest supply when mulching is absent.

The effect of soil sample depth on tomato seedling growth and the chemical/biological analyses for the ± mulch soils are summarized in Table 2.

TABLE 2

EFFECT OF SAMPLE DEPTH AND OF ± MULCH ON TOMATO GROWTH AND COMPARATIVE SOIL ANALYSES*

	+Mulch			−Mulch			±Mulch		
	0–4″	0–8″	0–12″	0–4″	0–8″	0–12″	0–4″	0–8″	0–12″
Growth % ..	100	85	39	25	27	12	63	56	25
pH	6·7	6·1	5·7	5·4	5·4	5·3	6·0	5·7	5·5
K (Meq.%) ..	3·1	2·8	2·2	1·5	1·5	1·2	2·3	2·1	1·7
Ca (Meq.%) ..	7·8	6·2	3·2	7·0	7·0	5·2	7·4	6·6	4·2
Mg. (Meq.%) ..	5·7	5·4	3·4	3·8	3·0	2·5	4·7	4·2	2·9
P (ppm)	40	35	15	15	13	10	27	24	12
N (%)†	26	38	3	50	43	37	38	40	20
P (%)†	84	67	56	54	61	50	69	64	53
S (%)†	74	84	84	93	93	87	83	89	86

NOTES—

(1) *Analyses by the Chemistry Section, Scott Agricultural Laboratories, Nairobi.

(2) †Biological analysis; per cent "Plus All" nutrient treatment.

(3) Growth expressed as a percentage of the 0–4″, +mulch sample over all the nutrient treatments (10) and three absolute replications.

At all sample depths the mulched soil has given much greater tomato seedling growth. This is particularly noticeable in the top 8 in. of the soil. Mulching the soil with Napier grass has substantially raised the soil pH (decreased the degree of soil acidity), the soil phosphorus (chemical and biological values) the exchangeable soil potassium and exchangeable magnesium. Again, these increases are particularly noticeable in the top 8 in. of the soil. Biological nitrogen values are difficult to interpret: lower values for the mulched soil suggest an adverse effect of organic matter during the short (two-day) test.

Two further 0-8 in. topsoil samples, ± Mulch treatment, were collected from plots in Manurial Trial IV on the Coffee Research Station. Napier grass mulch in the trial has been applied for five years prior to sampling. The soils were used to grow tomato seedlings in the micro-pot test as before. Comparative growth figures and chemical analysis data are summarized in Table 3.

TABLE 3

SUMMARY OF TOMATO SEEDLING GROWTH IN 0-8 IN. TOPSOIL SAMPLES ± MULCH, TOGETHER WITH THE RESULTS OF SOIL ANALYSIS

	+Mulch	−Mulch
Growth*	100%	65%
pH	6·8	6·1
K (Meq.%)	3·7	2·1
Ca (Meq.%)	12·6	13·8
Mg (Meq.%)	5·0	4·2
p (ppm)	40	36
N%	—	—
P%	62	62

NOTES—

*Growth expressed as a percentage of the 0–8″ +mulch soil over all pot treatments (10) and three absolute replications. L.S.D. (Means of 30)=8%***.

Again a substantial effect of mulch is to be noted. The soil pH value has been increased as have the exchangeable potassium and magnesium levels in the mulched soil. Phosphorus has only increased slightly in the short period of mulch application; this area was previously under a phosphorus fertilizer treatment trial which probably accounts for the unusually high chemical P level found in the —Mulch soil.

These results serve to emphasize the value of Napier grass mulch for improving mineral fertility on the Kikuyu red loam coffee soils. However, some of the beneficial effect observed with the tomato seedling growth must be attributed to improved soil structure, a difference which persisted in the potted soils throughout the 5-6 weeks growth period. No visual deficiencies were observed on the foliage of the tomatoes for any of the nutrient treatments except phosphorus in the —Mulch, —Phosphorus and —All treatments, in the first experiment.

When urea fertilizer was advised to the industry for ground application in the place of ammonium sulphate, because of the soil acidity factor, it was assumed that the nitrogen efficiency was the same in each fertilizer form. At the time when this policy change was advised two field trials were initiated to check this question.

On the basis of three seasons' results from these trials which are summarized here there is evidence to support the fact that nitrogen derived from urea fertilizer applied to the soil is not as efficient for coffee as nitrogen derived from the soil application of an ammonium type fertilizer (ammonium sulphate in these trials).

TABLE 4

YIELD RESPONSES TO UREA AND AMMONIUM SULPHATE FERTILIZERS
(IN CWTS. OF CLEAN COFFEE PER ACRE PER ANNUM)

NITROGEN	CATTLE MANURE			Mean
	C0	C1	C2	
N0	8·2 (9)	8·4	9·8	8·9 (27)
N1	9·0	9·1	10·4	9·5
N2	10·3	9·4	10·8	10·2

L.S.D's. for the following comparisons—

Means of 9 CoN1 − CoNo = 0·2*** cwts. clean coffee per acre.
CoN2 − CoN1 = 0·2*** cwts. clean coffee per acre.
Means of 27 N1 − No = 0·1*** cwts. clean coffee per acre.
N2 − N1 = 0·1*** cwts. clean coffee per acre.

NOTES—

1. Yields for the 1959/60 season have been calculated from cherry weights using 16·6% for the conversion of cherry to clean coffee. Data are means for 1957/58, 1958/59, 1959/60 seasons
2. Figures in brackets represent the number of figures in the mean.
3. *** = statistically significant at the 0·1% level.

TABLE 5

MULCH-AMMONIUM SULPHATE UREA TRIAL: COMPARISON OF THE EFFICIENCY OF UREA AND AMMONIUM SULPHATE FERTILIZERS ± NAPIER GRASS MULCH FOR CROP PRODUCTION. (MEAN YIELDS IN CWTS. CLEAN COFFEE PER ACRE PER ANNUM.)

		(1)	S/A	Split S/A	Urea	Split Urea	Mean
(1)	(*a*)	8·0 (8)	10·2 (8)	9·5	9·1	7·9	9·0
	(*b*)	5·9	7·5	7·4	6·7	5·8	6·7
Mulch	(*a*)	6·6	9·1	12·0	5·7	10·2	8·7
	(*b*)	5·6	6·8	8·5	5·2	8·0	6·8
Mean	(*a*)	7·3	9·6	10·8	7·4	9·1	
	(*b*)	5·8	7·2	7·9	5·9	6·9	
Grouped Mean ..	(*a*)	7·3 (16)	10·2 (32)		8·2 (32)		
	(*b*)	5·8	7·6		6·4		

NOTES—

1. (*a*) Data for 1956/7 and 1957/8.
   (*b*) Data for 1956/7, 1957/8 and 1958/9.
   The latter year was the first crop after the change to a new multiple stem pruning cycle.
2. Data under (*a*) are means of 4 replications over 2 seasons; data under (*b*) are means of 4 replications over 3 seasons.
3. The rate of nitrogen application was 92 lb. per acre per annum for each fertilizer type.

L.S.D's. (for (*a*) only).
S/A vs. Urea (32) = 1·9*.
(1) vs. S/A or Urea (16 vs. 32) = 2·3*.

Both these trials show greater apparent responses in crop yield to the ammonium form of nitrogen fertilizer than to urea when applied to the ground. Both 1957 and 1958 were years of exceptionally heavy rainfall, particularly the long rains periods during which the fertilizers were applied. The greater solubility of urea before hydrolysis to the ammonium form in the soil would act against its efficiency; a part of the application(s) might well have been washed down the soil profile out of the topsoil which has the greatest concentration of coffee feeding roots, before the nitrogen became available to the coffee. Because of this, further results from Manurial Trial 1 obtained for years of "normal" rainfall are necessary before a firm statement can be made. On the other hand, even in years of "normal" total rainfall, precipitation during the long rains may often be both heavy and of a prolonged duration. It is because of this that these results have been taken into consideration recently when not advising urea fertilizer for ground application. Ammonium or predominantly ammonium-type fertilizers with, however, a lower residual soil acidifying effect than ammonium sulphate, are much to be preferred as they are probably safer and more satisfactory in several respects.

The figures in Table 5 also illustrate some apparent beneficial effect on yield of splitting the nitrogen fertilizer dressing during the long rains period in the presence of a mulch. Splitting the total nitrogen fertilizer during the long rains in East Rift areas and during the rains elsewhere in the Colony, is now a recommendation to the industry; mulching is a common cultural practice over the greater part of the coffee acreage.

Field investigation has revealed a major source of "amber beans" from the coffee tree. Amber beans occur in clean green coffee from certain areas and for estates quite regularly over a number of crops seasons. They have been described as "smooth yellowish beans, cause unknown", sometimes giving rise to "pales" in the roast. It has been shown during the 1959/60 season that they occur specifically in normal looking ripe cherry from chronically iron deficient coffee trees, at a level of between 15-30 per cent of all the beans. More specifically, it would appear that bearing wood with iron chlorosed leaves on it, as opposed to bearing wood on the same tree with green leaves, is the source of amber beans. Bearing trees showing leaves with visual iron chlorosis (temporary) as the result of mineral unbalance (as differentiated from the chronic condition which is directly related to soil conditions) also produce amber beans but field sampling has revealed only a relatively low level, 1-4 per cent of all the beans.

Samples of "amber beans" were followed through the roasting and liquoring stages; it was demonstrated, with only a very limited number of tests, that in a given roasting time at a given temperature, they do not roast to the same degree as normal coloured, grey-blue coffee. This gives rise to an "uneven" appearance in a roast which contains amber beans. The liquors from roasted amber beans were described as "common" and "lacking in acidity" both characteristics result-in the lower grading and therefore a lower price when detected in commercial samples.

It is advised that in practice, ripe cherry from patches of trees suffering from a chronic iron deficiency condition should be picked separately during the harvesting of the main crop.

Various sets of coffee leaf samples taken from several trials on the Station have provided interesting information during the year. Thus, in one of the nitrogen fertilizer trials it has been shown that sodium nitrate fertilizer raises the level of sodium found in the leaves; in one of the mulch trials it has again been demonstrated that mulching will raise the leaf phosphorus level significantly.

This is presumably a combination effect, i.e. higher soil phosphorus, higher soil organic phosphorus and longer periods of available topsoil moisture, etc. From the same mulch trial it now emerges that the most significant influence of fertilizer nitrogen on leaf nitrogen levels is detected during the dry season, as the crop matures. Much more work is required before a detailed interpretation of these and similar results will be possible.

J. B. D. ROBINSON,
Principal Scientific Officer.

ANNUAL REPORT OF THE COFFEE BERRY DISEASE RESEARCH UNIT, 1959/60

Coffee Berry Disease

Field research has been increased during the year, although the main lines of approach have remained unaltered, attention being directed firstly to the precise timing of applications and secondly to the search for suitable fungicides. The latter have been successful only in so far as they have emphasized that copper formulations, when correctly timed, give good results and more consistent control than that achieved with Captan.

Timing trials have confirmed results from the past three seasons, namely that for all coffee-growing districts the period February-March is a critical one. In the Kiambu District it is the main one, and while trials (started in September, 1958) indicate that a yield response may be obtained by sprays applied in October and November, the major response is to the February-March sprays. In this district a 4 cwt. increase on an 11 cwt. crop has been obtained.

In the other districts studied (Mweiga and West Rift), the February-March period is also critical. In these districts, however, a second series of sprays is necessary in June and July. In the West Rift excellent results have been given by copper—an example being a 7 cwt. increase on a 6 cwt. crop.

In the laboratory the small amount of work necessary to complete previous investigations has been completed and part of it is in the press. A detailed investigation has been undertaken of the relation between meteorological factors and disease incidence, in relation to the known effects of these factors on the fungus. This has enabled the distribution of the disease and the effect of such factors as shade and topography on it to be related to standard climates and thus the probability of attack in any given climate can be predicted. A simple apparatus has been developed which integrates all the climatic factors concerned and which will enable precise local assessments of disease probability to be made. This work shows clearly the reasons why a double series of spray treatments is necessary in the West Rift districts and not in Kiambu.

Leaf Rust

Experiments, generally 2^5 factorials on time of application, have been sited over a wide range of altitudes and climatic zones. Most of these involved the use of Captan, this being known to give excellent control. It is now clear that this fungicide is satisfactory when applied over the period February-April, but observations on an experiment laid down for coffee-berry disease work have shown that copper applications in the period October and November remain effective over two or more epidemic cycles, whereas Captan is effective for one only. Consequently, in October, both the existing trials and certain additional ones have been redesigned to investigate in detail and comparatively the effects of copper in October-November and Captan in February and March.

These results, together with other field observations, are difficult or impossible to explain on the generally accepted theories on spore disposal. This has now been investigated in detail and it has been shown that the dispersal of the spores of this particular rust is not, in the main, by wind. The dry spores adhere to the pustule very strongly and winds of a velocity rarely encountered in the coffee districts are necessary to dislodge them. They are instantly liberated, however, by water. This work is now in the press.

A beginning has been made with the necessary laboratory study of the detailed effects of climatic factors on the pathogen. This is still in progress.

A detailed report on the work of the unit has been published for the Coffee Board of Kenya.

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GRASSLAND RESEARCH—ANNUAL REPORT FOR 1959

Section I—Review of the Year

At Kitale good progress was made on the selection of leafier and more vigorous types of Rhodes grass and *Setaria* as well as on the breeding behaviour of Rhodes and Star grass and of Kenya White clover and Rueppell's clover. The problems of ley management continued to receive attention from the viewpoint of full utilization of grass during the growing season and of setting aside pasture for grazing during the months of relative dryness. Identical twin cattle continued to be used for ley evaluation. Work on the major elements phosphorus, potassium, magnesium and sulphur in relation to plant growth continued under field and greenhouse conditions.

Seed multiplication made rapid strides during the year, and it is anticipated that this will favourably affect the commercial growth of seed during the coming year. It is pleasing to record that there is already a very considerable improvement in the quality of locally grown seed.

The plans made earlier in the year to increase the revenue from our high-altitude station at Molo without upsetting unduly the pasture research programme, are becoming effective and already there has been a gratifying increase in the output of butterfat, lamb and wool.

Work at Katumani and Marigat (formerly Kamasia) continued to progress. The former station is concerned with the management of natural grassland, the production of annual and perennial fodder crops, bush control by fire and by arboricides and with testing selected ley grasses under semi-arid conditions. The latter station is concerned not only with bush eredication but also with the very difficult task of reseeding denuded areas under arid or semi-arid conditions, and with the preservation of the natural ground cover by carefully controlled grazing schemes.

(1) Weather and Rainfall

The rainfall records for the year, together with those for the two previous years, are given below:—

Month	1959		1958		1957	
	Rainfall (inches)	No. of wet days	Rainfall (inches)	No. of wet days	Rainfall (inches)	No. of wet days
January ..	0·50	5	3·01	4	0·94	7
February ..	3·08	8	4·40	8	0·15	3
March ..	2·21	9	5·06	5	3·19	12
April ..	4·80	22	2·46	13	6·75	22
May ..	5·10	19	4·77	14	9·24	20
June ..	3·43	17	10·60	20	4·66	18
July ..	3·71	11	2·82	18	4·18	12
August ..	3·99	18	7·84	19	5·96	19
September..	3·84	19	4·35	13	1·24	9
October ..	4·88	17	4·85	16	1·22	10
November..	4·41	15	0·80	6	2·35	14
December..	0·35	2	0·92	6	1·77	7
Total ..	40·30	162	51·88	142	41·65	153

The total rainfall for 1959 was below average and although its distribution was fairly uniform, its effect on plant growth was not entirely satisfactory: grasses, legumes and cereals were all under stress at some stage of their respective growth cycles.

(3) Plant Introduction and Preliminary Grazing Trials

In 1959, 235 samples were tested in the introduction nursery. These included 40 varieties of Red clover (*Trifolium pratense*), 26 varieties of *Glycine javanica* and some new varieties of Rhodes grass (*Chloris gayana*). Of the Red clovers Montgomery late, Louisiana, Kenland, New Zealand certified, Medium red, and the Chilean formed good stands, well balanced with the companion grass. A variety of *Glycine javanica* from Eldoret (Kenya) showed very good results in the first year of growth. Other outstanding introductions were a perennial vigorous variety of *Dolichos lablab* which may perhaps be suitable as a companion plant for Elephant grass or Guinea grass; Pangola grass (*Digitaria decumbens*), which formed a very dense and leafy sward; a variety of *Paspalum commersonii* from Southern Rhodesia and a variety of Guinea grass (*Panicum maximum*) from Nyasaland.

One of the preliminary grazing trials which represents the second stage in the evaluation of pasture plants was completed in 1959 after four years of intensive grazing. Twenty species and varieties of leguminous plants were tested in duplicated .01 acre plots in mixture with Rhodes grass and Molasses grass; they were: Kenya White clover (*Trifolium semipilosum*), the Louisiana variety of White clover (*T. repens*), five varieties of Rueppell's clover (*T. rueppellianum*), Dwalganup, Yarloop, Tallarook, and Mount Barker varieties of subterranean clover, Crimson clover (*T. incarnatum*), *T. usambarense,* two varieties of lucerne, Sainfoin, *Lotononis bainesii,* Spanish clover (*Desmodium uncinatum*), a species of *Teramnus* and *Indigofera subulata.* The best results were obtained from the Louisiana White clover, lucerne, and the Spanish clover. The Louisiana white clover produced a well-balanced mixture with the companion grasses, especially with Molasses grass, survived throughout the four years of trial, and was productive in the wet seasons. The Hairy Peruvian and Hunter River varieties of lucerne grew well in the first two seasons with the Hairy Peruvian being the more vigorous. Recovery after each grazing was fast, and in the first two seasons both varieties were most productive and lasted well into the dry seasons. In the third season growth was retarded, but in the fourth year both varieties recovered again and remained productive. The Spanish clover developed slowly in the first season, but gained vigour steadily in the second and subsequent years and formed a well-balanced mixture with its companion grasses. It remained green and produced good grazing for a considerable portion of the dry season. Its palatability was satisfactory and it formed good nodules. Of the annual species the Dwalganup variety of subterranean clover which persisted well during the four seasons, and some less aggressive varieties of Rueppell's clover, showed satisfactory performance.

(4) Ley Plants and Ley Management

Ley Pasture Plants.—During 1959 the work of this section has been concerned primarily with various aspects of the growth and management of general purpose and late season leys, with arable forage, and with the influence of leys on the yield of the following crop.

General Purpose Leys.—An experiment, in which four legumes were being compared in mixture with Nzoia Rhodes grass, has now been completed. In this mixed swards of grasses and legumes have significantly outyielded grass alone during the 3½-year life of the pasture. The mean annual dry matter yields per acre

were:—Kenya White clover mixture 24 cwt.; Louisiana White clover 24 cwt.; lucerne mixture 25 cwt.; Rueppell's clover mixture 19 cwt.; and Rhodes grass alone 18 cwt. This result confirms earlier work in which grass-legume mixtures showed their superiority over grass alone. The three perennial legume mixtures yielded significantly more than the annual Rueppell's clover mixture, and this result suggests that perennial legumes may be preferable to annuals under these conditions.

The evaluation of grass species in replicated clipping experiments and in grazed pastures continues, and further evidence on the relative productivity of different grass species has been obtained. Thus, in a clipping experiment, the mean annual yield of leaf during the first two seasons expressed on the basis of cwt. per acre of dry matter was:— Molasses grass 65 cwt.; coloured Guinea (*Panicum coloratum*) 61 cwt.; Rongai Rhodes 56 cwt.; slender Guinea (*P. Maximum var. trichoglume*) 54 cwt.; Beck grass (*Beckeropsis uniseta*) 51 cwt.; Nandi *setaria* (*Setaria sphacelata*) 46 cwt.; Star grass (*Cynodon dactylon*) 43 cwt. The high yield of Molasses grass is of particular interest, as is also that of coloured Guinea, the latter having recently been brought into commercial supply.

In a critical comparison of Rhodes grass varieties "Chepararia", "Mbarara", "Endebess" and "Mpwapwa" have given higher yields of leaf during their first season than either the "Nzoia" or "Alego" varieties. The "Rongai" type has yielded slightly, but not significantly, less than the first four. The varieties differ somewhat in stemminess, as is shown by the following percentatges of stem contained in the full season's yield of herbage: "Chepararia", "Mbarara", "Endebess" and "Alego" each contained 19 per cent of stem; "Nzoia" 21 per cent; "Mpwapwa" 23 per cent; and "Rongai" 26 per cent. Analyses of the leaf has shown remarkably little variation in the crude protein content of the different varieties, which suggests that the ratio of leaf to stem probably determines the quality of Rhodes grass strains rather than inherent differences in the quality of the leaf.

Late Season Leys.—Work continues on the production of reserve forage for use in the "late season", or dry weather, and three experiments dealing with different aspects of "late season" leys were completed during the year. The object of these was to examine the influence of legumes on the dry weather production of slender Guinea grass; to compare the effect of different row spacings on the productivity of "Sigor" Guinea grass; and to compare varieties of Elephant grass. The results indicate: (1) that the use of certain drought resistant legumes such as *Glycine javanica* might be advantageous in areas where the dry season is not too severe; (2) that the row spacing of the vigorous Guinea grass varieties such as "Sigor" may, without loss of yield, be opened up to as wide as 8 ft. if required to facilitate cultivation. There is a tendency for the grass to give higher yields at wide spacings, but weed encroachment may thus be encouraged and a spacing of 4-5 ft. might therefore be about the optimum; (3) that the "Gold Coast" and "French Cameroons" varieties of Elephant grass gave higher yields of leaf than either the "Napier × Balaba" hybrid, "Minna", or "Uganda hairless" varieties, while the "Cameroons" strain was roughtly intermediate between these two groups.

Some interesting results are also coming from a clipping experiment in which the late season production of a number of grasses is being compared.

The mean yield of leaf dry matter in the first two seasons, from growth accumulated after August and harvested from January to March was "Gold Coast" Elephant grass 33 cwt. per acre; "Sigor" Guinea grass 32 cwt.; Molasses grass in 3 ft. rows 30 cwt.; Molasses grass in 6 ft. rows 28 cwt.; slender Guinea grass 26 cwt.; giant Setaria (*Setaria splendida*) 23 cwt.; "Nzoia" Rhodes in 6 ft.

rows 20 cwt.; "Nzoia" Rhodes in 3 ft. rows 16 cwt.; and Columbus grass (*Sorghum almum*) 15 cwt. Thus it appears that by appropriate management of suitable species under these conditions 1-1½ tons of dry matter per acre might be conserved in late season pastures for grazing *in situ* during the drier months. This is, of course, in addition to the grazing provided by these grasses during the main growing period.

Arable Forage.—From the viewpoint of arable forage production, "Velvet" sorghum was compared with several other varieties of annual and short-term perennial forage crops. The first flush was harvested at the "silage" stage and subsequent growth at the "grazing" stage. The plots were split for ammonium sulphate at the rate of nil, 150 lb., and 300 lb. per acre applied shortly after establishment. The yield of dry matter from the main treatments, for the silage cut only, was:— Velvet Sorghum and maize 71 cwt. and 67 cwt. per acre respectively, both of which were significantly higher than perennial Kavirondo sorghum and oats at 49 and 48 cwt.. while both these were significantly higher than Columbus grass and Sudan grass at 31 and 26 cwt. The mean crude protein content of the silage material, expressed as a percentage of the dry matter, was: Oats 15.5 per cent; Sudan grass 15.3 per cent; Columbus grass 14.5 per cent; perennial Kavirondo sorghum 12.7 per cent; velvet sorghum 12.3 per cent; and maize 10.7 per cent. The yield per acre of crude protein from the velvet sorghum was significantly higher than that from each of the other varieties at 971 lb., followed by oats and maize at 830 and 802 lb. respectively, these being significantly higher than perennial Kavirondo sorghum at 704 lb., which in turn was higher than Columbus grass and Sudan grass at 495 and 449 lb. respectively. The application of nitrogen resulted in slight but not significant increases in dry matter yield, while the increase in crude protein yield due to N. achieved significance. Velvet sorghum and P.K. sorghum were heavily attacked by maize stalkborer.

It has been noted that the low silage yield from Sudan grass appears to have been quite largely compensated for by its high production of aftermath grazing.

Test Cropping.—A barley test crop was drilled following the completion of a management trial on four grass/white clover mixtures. This trial, reported on page 6 of our 1958 cyclostyled annual report, showed that certain treatments encouraged the dominance of Kenya White clover while others suppressed it. It had been expected that differences in the proportion of clover might influence the yield of the following barley crop but no such influence was observed.

Interesting results have been obtained from a maize test crop that was planted following a comparison of grass-legume mixtures. The plots in the earlier trial had been split for gypsum, and phosphate had been applied at three levels: PO = control; P1 = 2 cwt. per acre of triple superphosphate in 1955 and 1 cwt. in 1956 and 1957; P2 = 4 cwt. per acre of triple superphosphate in 1955. No fertilizers were applied to the maize. The overall effect of the pastures on the maize yield was approximately 12 bags per acre following pure grass swards and 14 bags per acre following grass-legume mixtures .The overall effect of the phosphate residue was approximately 11 bags following PO, and 15 bags following the P1 and P2 treatments respectively. The gypsum residue, combined with the legumes and phosphate, had a pronounced effect on the yield of maize. Thus, where gypsum had been applied, the maize averaged about 13 bags an acre following pure grass swards, and 17 bags following mixed grass-legume swards, while the phosphate with gypsum residual effects were of the same order, viz.: PO = 13 bags/acre; P1 = 17 bags/acre, P2 = 18 bags/acre. In the absence of gypsum residual phosphate gave an average increase of only about two bags of maize, while the residual legume effect was negligible.

(5) Soil Fertility Studies

During 1958 a test crop of maize was taken from a long-term soil fertility experiment after the following treatments: (1) four years' continuous arable cropping; (2) four years under *Setaria;* (3) four years under a *Setaria*/Kenya white clover sward. The maize following the grass-legume break produced a significantly higher yield of grain than the corresponding crop following either continuous cropping or grass alone. This year differences in yields of maize due to treatments were non-significant.

In a parallel experiment a test crop of maize was taken in 1958 after four years of continuous cropping and after four years of Rhodes grass during which time the grass was subjected to different forms of management. The difference in yield of maize due to treatments was non-significant in 1958, and this same result has occurred again this year.

In 1958 an experiment was designed so that the effects of the nitrogen fixed by legumes on the amount of nitrogen produced by the companion grass (Nandi *Setaria*) could be compared with those of applying different rates of fertilizer nitrogen to the grass alone. The fertilizer used was N.A.C., a Belgian product containing 20.5 per cent N. and about 40 per cent Ca.

The mean results for the two seasons 1958-59 are shown below:—

The Effect of Legume Nitrogen and of Fertilizer Nitrogen on the Nitrogen Produced from Setaria. Mean Yield of Nitrogen (lb. per acre)

Setaria							
With Legumes			With Nitro Chalk			Alone	S.E.
Kenya white clover	Rueppells clover	Lucerne	1½ cwt./ acre	3 cwt./ acre	6 cwt./ acre		
213	207	200	175	223	322	132	12

The yield of nitrogen from the control is significantly lower than from all the remaining treatments and the yield from the 6 cwt. per acre N.A.C. is significantly higher than from all the remaining treatments. It would appear from these results that the yield of nitrogen from the *Setaria* growing with legumes is of the same order as that obtained by applying 2½ cwt. per acre N.A.C. to the grass alone. This result is somewhat lower than that which might be anticipated from grasses growing with legumes under temperate conditions.

(6) Animal Agronomy

An experiment to compare the effects of applying ferlitizers (N, P and gypsum) to a Rhodes grass/Kenya white clover pasture over a three-year period, viz., 1957-59, was concluded in mid-December. No fertilizers were applied in 1959 and effects were measured in terms of liveweight gains per head and per acre. For the year under review, these are given below:—

	No Fertilizers	Fertilizers
Lb. liveweight gain per acre (17 April–18 December)	248	473
Lb. liveweight gain per head (17 April–18 December)	8·0±1·1	9·0±1·2

The difference in the mean liveweight increase per head is non-significant but the difference in gain per acre is significant at the 5 per cent level. It is inevitable in an experiment of this kind, where animals are weighed weekly over a long period, that a high standard error will be introduced, and this experiment is no exception.

The economic value of the gain in liveweight increase per acre when fertilizers are used is doubtful and in so far as this experiment is concerned it is estimated that it has taken two years to recoup the original cost of the fertilizers applied.

An experiment in which *Setaria* and a *Setaria*/Louisiana White clover ley are being compared in terms of liveweight gains per acre has shown so far that the mean liveweight gain of 9.8 lb. per week from the mixed sward does not differ significantly from that of 7.4 lb. per week from the grass sward.

In another experiment, the grasses Rhodes, Molasses and Nandi *Setaria* were evaluated through twin cattle over a period of 35 weeks. The mean liveweight gains per acre (lb.) were respectively 237, 233 and 242, and the differences between these values are non-significant. The liveweight gains from each of the grasses was correlated with log. time. The slope of the *Setaria* curve differed significantly from that of the Rhodes and of the Molasses, but between these latter the difference in slope was non-significant.

Using two pairs of twin heifers, it was found over the short period of 29 days that the yield of milk obtained from a *Setaria* ley was significantly lower than that obtained from a *Setaria*/Louisiana clover ley.

(7) Seed Production and Seed Certification

With the addition of three large fields ploughed for seed production, the total area now under cultivation is 85 acres, and in order to provide more "Mother" seed for the Seed Certification Scheme, larger acreages of the more common species grown commercially were planted, as well as 70 small plots of the more promising species required for further trials.

The principal species now being grown are: Rhodes grass, viz., Mbarara, Endebess, Nzoia, Mpwapwa, Chepararia, and Alego varieties; Nandi *setaria;* slender and coloured Guinea grasses; Molasses; *Bothriochloa insculpta; Brachiaria ruziziensis; Cenchrus setigerus;* and *Enteropogon macrostachyus*; Kenya White clover; Louisiana and Bamenda White clover; *Trifolium rueppellianum,* and Hubam sweet clover. Roots of lawn grasses, and fodder grasses such as Elephant grass and *Setaria splendida* were in great demand throughout the planting season.

Yields of seed were satisfactory, though not as good as last year. Nandi *Setaria* yielded very poorly owing to a heavy infestation of Bunt disease (*Tilletia echinosperma*). Kenya White clover and Rueppell's clover were most disappointing and produced large numbers of shrivelled, infertile seeds, probably owing to lack of pollination by bees.

Only two farms have so far produced seed that has been approved under the Seed Certification Scheme. Both farms occur in the Kitale District, and they grow the Mbarara and the Nzoia varieties of Rhodes grass. Several farms in the Rift Valley were inspected for Dalgety & Co., but none of these produced seed that came anywhere near the standard required for certification.

(8) Pasture Chemistry

Water-soluble Phosphorus.—An examination of the water-soluble phosphorus contained in plants shows that the amount measured is controlled by bacterial activity, by the state of subdivision of the plants and by the stage of growth of

the plants. This latter, in turn, influences the distribution of the phosphorus. Using Star grass sampled at weekly intervals over a period of eight weeks it was found that the total phosphorus and the water-soluble phosphorus contained in the dry matter of this grass are directly related to the stage of growth of the grass. The following equations express these relationships:—

$$\text{Total } P = 0.515 - 0.044 \times t \quad (1 - r^2 = 0.032)$$

$$\text{Water-soluble } P = 0.480 - 0.041 \times t \quad (1 - r^2 = 0.038)$$

where t = time, in weeks. The difference between the slopes of these regressions is non-significant and the residual, unextracted phosphorus is given by the difference between the two constants and is 0.035 per cent. Throughout the sampling period the ratio water-soluble/total phosphorus was 0.928 ± 0.013.

The faeces of Jersey cows in milk were found to contain significantly higher amounts of total phosphorus and of water-soluble phosphorus than the mixed feed from which they were derived, but the ratio water-soluble/total phosphorus was significantly lower in the faeces than in the feed. From this it may be inferred that there is a loss of water-soluble phosphorus to the animal, as is only to be expected as part of the normal digestion processes. Regression coefficients for water-soluble on total phosphorus in the feed and faeces were not, however, statistically different, viz.:—

$$\text{Water soluble P in feed} = 0.76 \times \text{Total P in feed} + 0.00087 \quad (1 - r^2 = 0.007)$$

$$\text{Water-soluble P in faeces} = 0.746 \times \text{Total P in faeces} - 0.16818 \quad (1 - r^2 = 0.125)$$

Gross Energy

The gross energy contained in two grasses, two cereals and a legume grown at Kitale was measured at weekly intervals throughout their growth to maturation. It was also measured in 50 different nursery grasses which this year had been sampled at the early flowering stage of growth. The results of these measurements are given below.

Gross Energy (kg-cal. per g.)

Plant	Number of Samples	Stage of Growth	Gross Energy	S.E.
Lucerne	9	advancing stages of growth from young material to mature herbage	4·58	0·014
Wheat	17		4·35	0·041
Barley	17		4·36	0·019
Hyparrhenia dissoluta ..	10		4·15	0·021
Cynodon dactylon:				
1st series	15		4·23	0·017
2nd series	10		4·15	0·027
Nursery grasses	50	early flowering ..	4·24	0·018

It is apparent that the gross energy contained in the grasses, cereals and legume which had been sampled at advancing stages to maturity is remarkably constant for each of the species concerned. This result would seem to imply that "stages of growth" can have but little influence on the gross energy per unit weight of plant material. Similarly for the 50 nursery grasses which were sampled at the early flowering stage of growth, gross energy is also remarkably constant. There are of course differences between individual materials, as for example

between lucerne and wheat and wheat and the nursery grasses. These differences, though small, achieve statistical significance. From the standpoint of energy utilization by farm animals, the so-called "gross digestible energy", it is doubtful if the differences shown here are very important.

Plant Composition

The joint experiments with Mr. J. Glover of E.A.A.F.R.O. are almost complete and some interesting generalizations can now be made. We find, as others have found, that the percentage content of nitrogen (N), phosphorus (P), and sulphur (S) and of total carbohydrate (CHO) vary with age and water status of the plant. When plants are growing actively without serious check, the percentage total carbohydrate content of the dry matter increases with age whereas N, P and S decline with age. The combined effects are most easily demonstrated by the changing ratios of one to the other. Since these results are to be reported in detail elsewhere, only one of the ratios, the total carbohydrate/nitrogen ratio, is illustrated here. It shows the common pattern which is apparently found in all plant materials which have grown normally.

Since carbohydrate and organic nitrogen (substantially the crude protein — N × 6.25 — of the animal nutritionist) constitute the bulk of the dry matter of plants, it can be shown that in unit weight of such material the sum of these components is approximately 91 per cent. Thus, in theory—

CHO = 91 — Crude protein (c.p.) on a dry matter basis.

In practice we find from our analysis of grasses and legumes of all ages and stages of growth that—

CHO = 91.5— 1.2 c.p. ($1 - r^2 = 0.01$, n = 52).

We find also from our analysis of fodder trees and shrubs, including twigs, flowers, berries and the bark of branches, etc., that—

CHO = 88 — 1.0 c.p. ($1 - r^2 = 0.36$, n = 49)

and from the data in Schneider's "Feeds of the World" we have calculated that—

CHO = 92 — 1.3 c.p. ($1 - r^2 = 0.20$, n = 1300).

This indicates the good agreement between theory and practice. All equations may be divided throughout by c.p. to obtain the ratio CHO/c.p. as a function of crude protein. Thus the theoretical equation is CHO/c.p. = 91/c.p. — 1 or, as found in practice using Schneider's records CHO/c.p. = 92/c.p. — 1.3. If CHO/c.p. ratios are calculated from each of these equations at different levels of crude protein, say from 2-40 per cent c.p., and these ratios are plotted against the respective crude protein value, it is seen immediately that the two curves so obtained lie almost one on top of the other. If we now superimpose on them the actual records which we obtained by the analysis of our Kenya plants, viz., lucerne; a good grass and a poor grass, which were sampled from very early growth to maturity, we find that the records for each plant occupy a different portion of the general curve and that each set of records overlaps another. Thus while plants may differ in their carbohydrate/crude protein ratios during growth the different ratios all conform to a simple general overall pattern.

In the same manner a common pattern of CHO/P and CHO/S ratios may be demonstrated.

Although these results are of interest from the standpoint of plant growth, they are also likely to prove of interest in animal nutrition, for it can be further shown that there is a relationship between the CHO/c.p. ratio and the "nutritive ratio" of the animal nutritionist. The nutritive ratio (N.R.) is a similar ratio in

terms of digestible nutrients since it is the ratio of digestible non-protein to digestible protein. We find that it may be calculated from the CHO/c.p. ratio by means of an equation such as the following:—

$$\log N.R. = 1.31 \log CHO/c.p. - 0.13.$$

This equation implies that there is a relationship between total and digestible carbohydrate as well as as between total and digestible protein. This aspect has not yet been investigated.

Section II—Grassland Research Station, Molo

The rainfall this year has been below average and badly distributed, with a result that growth and establishment on experimental plots has been very poor. Nevertheless some progress has been made and some interesting results have been obtained.

It has been amply demonstrated that legumes need phosphorus. In "the forms of phosphate trial", now in its second year, strong residual responses to phosphorus were obtained with subterranean clover. Rock phosphate responses, although significantly better than control, were significantly lower than the responses from the other forms of phosphate, viz., triple superphosphate, Kenaf and basic slag, all of which were almost identical. Results expressed in cwt. fresh material/acre are summarized below:—

Control	Rock phosphate (high level) ≡600 lb. triple superphosphate per acre	Other forms (low level) ≡400 lb. triple superphosphate per acre	Other forms (high level) ≡600 lb. triple superphosphate per acre	S.E.
14·8	59·0	163–172	232–239	13·7

A trial to study rates of application and residual effects from triple superphosphate, using subterranean clover, was laid down this year. This experiment has given a well-defined response curve with significant differences between each rate of application up to 600 lb. triple superphosphate/acre, i.e., about 252 lb. P_2O_5. The maximum point of the curve lies between 600 and 800 lb. triple superphosphate/acre. The greatest response per unit of phosphate is between 100 and 200 lb. triple superphosphate per acre, and this is likely to be the most economic rate of application.

Results from major and trace element trials have shown once again that any shortages of the latter are marginal and that phosphorus and calcium are the really important elements required. Significant magnesium responses have been obtained in the presence of phosphorus and there are indications that copper may give a field response. None of these responses is however striking, either visually or from the yields of dry matter obtained. In the nutrient grid where major and trace elements have been applied in the presence of phosphorus and also in the presence of all the other elements of importance, no visual differences at all occur except in the phosphorus series.

Selections from a collection of spaced plants of *Trifolium burchellianum var. johnstonii* have been made and some outstanding plants have been obtained. This species, which is indigenous and nodulates well, has the potentialities of

becoming a valuable ley legume and seed production will be started next year. Strains of *Phalaris tuberosa,* at present under observation, are most promising and this species may have a place at the higher altitudes. Some preliminary selections of good flowering strains of cocksfoot have been made.

Section III—Grassland Research Station, Katumani

1959 was the first dry year since Katumani started. The rainfall of 23.49 in. was about average and much was learned about the performance of crops and grasses under more normal conditions. The months of highest rainfall were March (5.5 in.); April (3.2 in.); May (4.4 in.), and November (6.2 in.). The months June to October, both inclusive, produced a total of less than ¼ in.

The dry conditions provided a good test for ley grasses in preliminary grazing trials and Rhodes grass, which was only two years old, died out to a large extent. The most promising grass for general use is *Cenchrus ciliaris* and trials have shown that it can be satisfactorily established by broadcasting provided the land is clean. A Cambridge roller was found useful in preparing a good seedbed. The two best varieties of *Cenchrus ciliaris* appear to be Biloela and Mbalambala. The former is a quick growing erect type with abundant rhizomes. The latter is a very palatable, prostrate type with fewer rhizomes. Seed tests have shown the necessity for allowing about six months to elapse for seed to mature.

Preliminary information has been obtained on the seed rates to use with *Cenchrus ciliaris* and the main problem for study is the control of weed growth during establishment. So far no grazing legumes have proved satisfactory for inclusion in the sward.

An experiment on annual fodder crops for silage which was repeated for three seasons showed that maize and Sudan grass are the most suitable crops at present available in this area for silage, though bulrush millet will yield as well as maize in a season of low rainfall. Local sorghum and perennial Kavirondo sorghum are not recommended because of susceptibility to sorghum shootfly. Maize generally outyields Sudan grass by about 30 per cent in production of dry matter but Sudan grass provides valuable aftermath grazing which stays green in dry weather.

The following yields were obtained with a rainfall of only 7½ in. to harvest, on plots which received 200 lb. triple superphosphate per acre and 150 lb. sulphate of ammonia per acre.

	Maize	Local Sorghum	PK Sorghum	Millet	Sudan Grass	Mean	S.E.
Weeks from germination to harvest ..	9	10	10	9	10	—	—
Green yield (tons/acre)	16·6	9·5	10·6	13·7	9·0	11·9	0·9
Dry yield (tons/acre)	2·6	1·6	2·4	2·7	2·0	2·2	0·2

An experiment with perennial fodder grasses showed that Guinea grass from Mackinnon road can yield nearly as well as the best Elephant grass varieties and that it is less susceptible to drought and termite attack.

Columbus grass has not proved satisfactory at Katumani due to its low yields and to its susceptibility to rust. It appears to be suited to heavier soils in warmer areas.

A burning experiment at Katumani showed the value of burning in opening up dense bush and allowing grass to establish itself in thickets. A big reduction in numbers, particularly small seedlings, of *Wedelia* sp. resulted from burning. Other species such as *Crotalaria saxatalis* and *Acalypha fruticosa* regenerated very slowly but *Acacia brevispica,* one of the most objectionable species, regenerated up to 6 ft. a year or more after burning.

A similar experiment on burning whistling thorn at Konza showed that this species is very resistant to fire even in the seedling stage. Many of the ill effects on the grass sward attributed to burning appear to be due to the excessive concentration of game on burned areas when the grass is regenerating.

Arboricide trials at Makueni have shown that in certain circumstances 2, 4, 5-T can be fairly effective against *Acacia brevispica* but results do not warrant large scale applications at present.

Section IV—Grassland Research Station, Marigat

The station continues to provide a decentralized experimental approach to the grassland problems of the semi-arid African areas of the Rift Valley Province. Throughout 1959, primary attention has been given to the rehabilitation and management of natural grassland and all current experimental work is confined to Baringo and Samburu Districts. At the request of the Water Resources Authority, a survey was made of "The Vegetation of the Lower Uaso Nyiro".

Work on natural grassland has included the recording of botanical changes within controlled grazing schemes, and a series of four broken-belt transects, sited within the Seya-Barsalinga Grazing Scheme, Samburu, and designed to cover three recognized ecological divisions, were recorded in January, 1959, to indicate the condition of the land at the beginning of grazing control. Specific frequency recordings show that over 20 species contribute to the grass flora. The following have a frequency of occurrence over 2 per cent, and are listed in order of rank: *Cynodon plectostachyus, Eragrostis barrelieri, Latipes senegalensis, Aristida keniensis* (including some *A. ascensionis*), *Cynodon dactylon, Tragus berteronianus, Sporobolus pellucidus, Cenchrus ciliaris, Brachiaria leersioides, Digitaria macroblephara.*

The selection of grasses suitable for reseeding denuded grazing lands has been intensified, using for the purpose the Marigat nursery. An adverse season imposed considerable stress on the material included and from a total of over 50 grasses planted, only five showed particular merit. These were *Cenchrus ciliaris* ex-Kitale (M.5724), *C. ciliaris* ex-Lomelo (M.5824), *C. setigerus* ex-Kitale (M.5714), *Chloris gayana* ex-Karpeddo and *Tricholaena eichingeri* ex-Akoret.

Experimental work on the technique of reseeding continued during 1959 at Baringo and on the Njemps Flats. At Baringo, due largely to a season of restricted rainfall, there has been no significant increase in plant numbers since the end of the 1958 season. Changes that have occurred have been restricted to the further levelling of treatment differences and to variations in botanical composition. The variation between sites, noted earlier, continues to be maintained.

The 1959 season on the Njemps Flats emphasized the importance of cultivation to the establishment of a grass cover, and records show clearly that only where maximum cultivation preceded reseeding, has the grass cover increased. Further data from this experiment indicate the benefit to be derived from using cut branches to provide a protective cover for the establishing grass. Without such branches the grass population decreased over the year by 36 per cent as against 8 per cent where branches were used.

Bush clearing experiments were undertaken at Kisokon and Esageri. In the former trial, which was completed in 1959, neither of the two Holt machines, the VIa and the VIIIb, had any significant killing effect on regenerating *Tarchonanthus/Acacia* bush. Indeed it has become apparent that the machines encouraged the increase of young trees, for the regression of bush population on time is highly significant. It has also become apparent that of the bush species present, *Acacia nilotica* subsp. *subulata, A. senegal* and *A. seyal* var. *seyal* have increased at a greater rate than *A. brevispica* and *Tarchonanthus camphoratus.*

At Esageri the Holt IXa machine was used, and records made in September, 1959, show that no significant differences in bush population due to clearing have resulted. Since October, 1958, there has been an overall increase of 24 per cent in the bush population, bringing the mean number of trees per acre to 749. Only 16 trees from a total of 6,007 have failed to regenerate following clearing.

In another experiment at Esageri it was found that where plots had been thinned before burning a more even fire resulted and fewer trees remained unaffected. Following the burn 69 per cent of the trees regenerated from the base alone and 4 per cent from top growth also; 25 per cent remained unaffected and 2 per cent died.

A ley-grass trial was put down at Chemogoch for the purpose of studying areas of higher potential in which individual holdings are being developed. *Chloris gayana* appears to be the species best adapted to the area and four varieties, namely Endebess, Rongai, Mpwapwa and Mbarara have been selected for further trial.

The Marigat Herbarium now possesses 800 specimens, and five grass species have been identified as being new to Kenya. *Acacia doliocephala* Harms., collected in the West Suk this year, is also a species new to Kenya.

Section V—Publications

Bogdan, A. V.—The Selection of Tropical Ley Grasses in Kenya: General Considerations and Methods. *E. Afr. agr. J.* (1959), *24,* 206.

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Bogdan, A. V., Poultney, R. G. and Strange, L. R. N.—Notes on Kenya Agriculture VI—Grass Leys and Grassland Plants. *E. Afr. agr. J.* (1959), *24,* 223.

Birch, W.—High Altitude Ley Agronomy in Kenya, Pt. 1—Observations on the Climate and Soil. *E. Afr. agr. J.* (1959) *25,* 35. Pt. II—The Effects of Phosphates and Nitrogen. *E. Afr. agr. J.* (1959), *25,* 113.

Dougall, H. W.—The Acid Fibre Content of Lucerne in Relation to the Conventional Crude Fibre Content at Different Stages of Maturity. *E. Afr. agr. J., 25,* 78.

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ANNUAL REPORT OF THE SENIOR HORTICULTURAL OFFICER, 1959

Review of the Year

The Horticultural Products Committee, appointed by the Minister for Agriculture to advise him on problems of horticultural marketing and production, held its first meeting in May, and in all ten meetings were held. The task of co-ordinating the different interests in the horticultural industry is a heavy one, but the Committee has made a start, and has made a number of recommendations to the Minister.

Advisory research committees composed of producers, processors, marketing interests and research staff have been appointed for the Thika and Molo Stations. Both Committees met during the year to discuss the research programmes of the two stations, and to see for themselves the work being carried out.

Exports

Exports of horticultural produce by air, mainly to the United Kingdom and Aden, increased both in variety and quantity. Kenya luxury produce is now well known in Covent Garden, and judging by the favourable comments of importers it has established a good reputation there. The value of the London trade in terms of money is not large, limited as it is by the high cost of air freight, but the prestige value to Kenya is very considerable. Aden, in contrast to London, is not a luxury market. The quality of the produce exported there, though good, is not of the extremely high standard required for London, and includes kinds of produce which we could not sell in the latter market.

A considerable improvement has been made in the quality of fresh pineapples arriving at Covent Garden. This has been achieved by allowing the fruit to ripen on the plant, by improved methods of handling, and by dispensing with artificial colouring by gas treatment. The quantity exported by air was 111 tons.

Exports of avocados by air to London have been very successful, both with the varieties Puebla and Fuerte, although the latter variety is the best known and will sell in preference to any others. The highest net return to the grower in Kenya was Sh. 1/25 per avocado.

In a co-operative trial with two commercial growers regular consignments of French beans were successfully exported by air to Covent Garden from the middle of November onwards to meet the demand during the winter months when prices are high. They gave a profitable net return to the grower of Sh. 10/97 per carton of 10 lb., and it is likely that this trade can be considerably expanded.

Exports of passion fruit produced by African growers in the Machakos District, and packed by the Horticultural Co-operative Union, realized net prices up to Sh. 1/84 per dozen.

Imports

During the last three years there has been a very big increase in the value of fruit imported into Kenya from outside East Africa. The total value of imports in 1956 was £130,610, whereas in 1959 it was £243,588, an increase of about £113,000. A great part of the fruit imported could have been produced locally,

with consequent benefit to the economy of the country. Serious consideration should therefore be given to ways and means of increasing local production of some of the imported items. An indication of what can be done in this way is revealed by the value of the onion imports which fell over the same period from £88,806 in 1956 to £17,269 in 1959, a decrease of £71,537. This has been brought about largely by restricting the quantities of onions which may be imported from outside East Africa, and by a campaign to increase local onion production which is still being carried on by the Department of Agriculture There are still large imports of Tanganyika onions, but as these are generally of low quality it is not expected that they will compete seriously with Kenya production.

Tomatoes

The acreage of canning tomatoes decreased considerably when the purée plant in the Nakuru area was closed down. The present acreage is confined to areas of Central and Southern Provinces within the range of the Thika cannery and is mainly for tomato juice production.

Strawberries

The fall in local prices predicted in the 1958 report took place towards the end of the year. This might have been avoided if more of the fruit produced had been of export quality. In fact only a very small proportion was suitable for export.

Pineapples

In 1959, 11,005 tons of pineapples were processed by the canners in Kenya. This level of throughput is not considered to be sufficient for economic running of the canning factories, and a concerted effort is being made to increase plantings in order that the factories are worked to their full capacity. The target tonnage required to reach this position is 20,000 tons by 1961 and 30,000 tons by 1963.

Citrus

Investigations were continued in connexion with the proposed citrus juice industry. Commercial assessment of samples of lemon and lime juice submitted was favourable.

Record of Investigations

Tree Crops

Deciduous Fruits

The performance at Molo of the more promising varieties of deciduous fruit is shown in Table 1. All the trees were planted in 1946/47, with the exception of seedling peach which was planted in 1950.

In 1959 the gross return per acre was at the rate of Sh. 3,035 for peaches, Sh. 2,140 for plums. Production costs, including packing and transport, are approximately half the amount of the gross return. (4) (5.)

TABLE 1—MEAN YIELD OF DECIDUOUS FRUIT TREES

Kind	Variety	Rootstock	Average Annual Yield lb. per Tree	Number of Years Fruiting
Apple	Blenheim Orange	Cape Seedling	52	8
	Abundance..	Crab	35	8
	Bramley's Seedling ..	Crab	34	7
	King of Tomkin's County	Crab	30	8
	Sharp's Early	Crab	25	7
Pear	Keiffer	Own Roots	52	7
Plum	Settler	Own Roots	222	9
	Jardines Early	Own Roots	195	9
	Tazagine	Own Roots	195	9
	Methley	Own Roots	135	9
	Wilson	Mariana	103	8
Peach	Alexander Jewel	Peach	118	5
	Angel	Peach	85	4
	Muir	Peach	46	6
	Seedling	Own Roots	38	4

CITRUS

The mean yields of fruit at the Kitale sub-station for trees planted in 1950/51 are given in Table 2. Temperatures in this area are probably too low for very high yields to be obtained and growth of the trees is rather slow. A compensating factor, however, under these temperature conditions is that oranges develop a very attractive skin colour. The better quality oranges are considered to be Washington Navel, Renmark Navel and Sabina, in that order. The quality of grapefruit, again due to low temperatures, is poor, and commercial planting in the area is not recommended. The increase in yield as a result of irrigation is not marked at present, but observations will have to be continued over a longer period before final conclusions can be drawn on its effects. (4) (5.)

At Jacaranda substation the citrus trees planted in 1951 on Kikuyu Red Loam are showing definite signs of "decline". This is reflected in the yields of fruit which are not generally giving the annual increases normally expected. Most trees show a very poor leaf colour, excessive leaf drop and die back, and very little new growth. The major factor for this "decline" is attributed to unfavourable soil conditions. Examination of the root systems revealed that the main roots were confined to the dark red top soil, which was rarely more than 1 ft. in depth, and that there was very little root growth into the red subsoil. Mechanical analysis showed that the red subsoil had over 75 per cent fine silt and clay fractions, and it would seem that either the citrus roots are unable to penetrate such a fine soil or else there is insufficient root aeration. A further contributory factor for this "decline" is probably an abnormally rapid build-up of root destroying pathogens due to the root systems being confined to the small volume of top soil. It is clear that soils of this type are unsuitable for citrus growing and should be avoided. (2) (3.)

TABLE 2—MEAN CITRUS TREE YIELDS (KITALE)

Kind	Variety	Average Annual Yields lb./tree		Number of Years Fruiting
		Irrigated	Unirrigated	
Orange	Washington Navel	64	59	4
	Sabina	66	21	3
	Renmark Navel	32	41	4
	Parson Brown	129	61	4
	Hamlin	104	60	4
	Valencia Late..	78	50	4
Lemon	Villa Franca	254	167	5
	Eureka	136	103	3
	Meyer	117	142	5
Grapefruit	Marsh Seedless	177	201	4
	Triumph Seedless	135	97	4
	Triumph Seeded	79	99	4

At Perkerra experiment station, irrigated citrus make about twice as much growth a year as at Kitale, due to the high temperatures in this area. For the same reason the skin colour of oranges is poor. Grapefruit is doing extremely well and a very favourable report on fruit quality has been received from a local cannery. With the exception of oranges, citrus comes into bearing very early at Perkerra. The mean tree yield in the fourth year from planting is given in Table 3.

TABLE 3

Kind	Variety	Average Yield per Tree/lb.
Grapefruit	Marsh Seedless ..	92
	Triumph Seedless ..	48
Lemon	Eureka	115
	Villa Franca	234

(4), (5), (7)

CITRUS JUICE INDUSTRY

The number of lemon juice samples sent to Messrs. Schweppes' laboratory in England for commercial assessment now totals 54. The conclusions which can be drawn from Messrs. Schweppes' reports are that juice of acceptable commercial quality could be produced at all seasons of the year in the climatic zones covered by Jacaranda substation, Machakos District, and the area around Lake Naivasha. Juice should be produced only from certain standard lemon varieties. Lisbon consistently produced the highest quality juice, with Villa Franca second. As Lisbon is a vigorous grower and a heavy yielder, it is the obvious choice of variety for lemon juice production.

Messrs. Schweppes also reported very favourably on two samples of Mexican lime from Matuga.

Difficulty was experienced in producing lemon oil samples of adequate size by the ecuelle method. Some oil has been produced at Thika by scraping the rind with the back of a knife. A small oil press on the principle of the improved sponge process is being made at Thika. A report on small samples of oil sent to the Tropical Products Institute was not unsatisfactory, but larger samples are required. (1.)

Avocados

In contrast to citrus, avocados at Jacaranda are doing well. Examination of the roots shows a very good distribution to a depth of 5 ft. The trees are much larger and bear considerably heavier crops than the corresponding planting at Kitale.

Samples of avocado oil have been extracted by the East African Industrial Research Organization from fruit produced at Jacaranda. The samples are being distributed to the trade for commercial assessment. (1.)

Pineapples

The main pineapple plantings at the Horticultural Station, Thika, were carried out in June/July, 1956, when 10.2 acres were planted on what was considered to be fertile virgin red-Kikuyu loam. The plants were slow to establish themselves, and since they continued to make poor growth a dressing of 500 lb. per acre of sulphate of ammonia was applied in May, 1958, and a similar application was made the following November.

Harvesting of the plant crop commenced in March, 1958, and was completed by July, 1959. The total yield on this acreage was 42.7 tons Grade 1, 64.5 tons Grade 2, and 9.8 tons Grade 3, which gave a mean total yield of 11.5 tons of fruit per acre.

The low yield was the result of a misjudgment of the fertility of the soil, and the fertilizer was applied too late to rectify this. The plants continued to make poor growth and the yield from the first ratoon crops will again be very low.

There are probably few, if any, virgin soils of high fertility remaining in the Thika area, and new plantings will be made on replant areas or land of low fertility. Under these circumstances growers would be well advised to carry out a standard programme of four nitrogenous dressings—each equivalent to 500 lb. of sulphate of ammonia per acre and within one year of planting. Pineapples do not respond to late remedial dressings of fertilizer and unless such a programme is carried out the results from new plantings are likely to be disappointing.

Plant Material Trial 1, Ruiru

This trial was started in May, 1955, to compare different types and sizes of planting material. The plant crop was harvested by January, 1958, and the details were published in Vol. II of the Annual Report for 1958. The harvesting of the first ratoon crop was completed by March, 1959, or 48 months after planting, and the results are given in Table 4.

There is no significant difference between the yields of the ratoon crop or between the total yields of the plant and ratoon crop of the different treatments. Any interpretation of these results must therefore be viewed with caution.

The general trend has been for the sucker material to yield higher than the slips—the large and mixed suckers giving the best results. The main contributory factor for this result has undoubtedly been the greater number of fruits produced by the suckers compared to the slips and this is especially so with the small slips which gave the lowest yield.

TABLE 4

TREATMENTS	1ST RATOON CROP				PLANT + RATOON CROP	
	Weight of planting material	Mean weight fruit/lb.	Yield Tons per acre	No. fruits per acre	Total yield tons/acre	Total No. of fruit per acre
Mixed crowns ..	2 oz.–4 oz.	2·54	14·8	12,720	39·3	29,295
Uniform crowns ..	4 oz.	2·62	16·8	13,568	42·4	30,143
Small slips ..	1½ oz.	2·63	13·4	11,024	33·3	25,899
Medium slips ..	2½ oz.	2·72	15·6	12,720	38·3	28,870
Large slips ..	6 oz.	2·89	16·9	12,720	39·5	28,445
Mixed slips ..	1½ oz.–6 oz.	2·78	15·9	12,720	36·4	26,745
Small suckers ..	4¾ oz.	2·71	18·1	14,840	41·8	31,415
Medium suckers ..	10 oz.	2·48	17·6	15,688	44·6	32,263
Large suckers ..	19 oz.	2·52	17·7	15,265	48·0	31,839
Mixed suckers ..	4¾ oz–19 oz.	2·64	18·2	14,840	48·6	30,143

The first ratoon harvesting pattern of the three main types of planting material is given in Table 5.

TABLE 5

PERCENTAGES HARVESTED ON A MONTH-TO-MONTH BASIS (CUMULATIVE)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1. Uniform crown..	Nil	Nil	1	3	3	5	31	34	44	61	65	59	81	99	100
2. Large suckers ..	38	47	63	65	65	66	73	75	78	87	87	90	92	98	100
3. Large slips ..	Nil	3	12	14	14	18	33	38	44	52	57	61	77	93	100

The bulk of the first ratoon crop (94 per cent) was harvested from the crowns over a period of eight months, whereas the slips took 12 months and the suckers 18 months. The final date of completion of the first ratoon crop of all the treatments was about the same. In conclusion this trial compared suckers with relatively small slips and it is considered that better results would have been obtained with slips of over 6 oz. in weight. However, further trials will be necessary to establish this point. (2) (3.)

Berry and Other Fruits

STRAWBERRIES

Rotational Manurial Trial, Molo

This trial was put down in August, 1958, to enable a study of crops that may economically follow a strawberry cycle when certain manurial treatments were applied. A feature of the manurial treatments was to make up the nutrient equivalent of 40 tons FYM by using 20 tons of FYM with green manure, or wheat straw fortified with NPK.

The first phase of the trial is one cycle of strawberries, variety Cambridge Early Pine, which will produce four crops at intervals over a three-year period. Cropping was controlled in the first year to a two-month period following an eight-month deflowering period after planting. After the first crop the plants were deflowered for a period of six months, this will be followed by the second cropping period of two months, and the cycle will be continued in this way until four crops have been harvested.

The manurial treatments were as follows:—

A—40 tons FYM per acre

B—20 tons FYM per acre plus 867 lb. sulphate of ammonia plus 237 lb. double superphosphate plus 409 lb. muriate of potash.

C—Green manure grown *in situ* as wheat.

D—Green manure grown *in situ* plus 1,235 lb. sulphate of ammonia plus 226 lb. double superphosphate plus 267 lb. muriate of potash per acre.

E—6 tons of wheat straw per acre plus 1,278 lb. of sulphate of ammonia plus 467 lb. double superphosphate plus 778 lb. muriate of potash.

Harvesting of the first crop commenced during April. The yield results are based on a spacing of 1 ft. x 2 ft. and are shown in Table 6.

Table 6—Strawberry Rotation and Manurial Trial
Summary of Yield Results

Mean Yields	A	B	C	D	E	Mean
lb./acre ..	3,014***	1,712	1,918	2,260	1,301	2,041

(*** Significant at P = 0.001)

The A treatment representing the 40 tons FYM has shown this treatment to be by far the best. (4) (5.)

Fertilizer Trial, Molo

This trial, which is a 3^3 factorial design, was planted in September, 1958, to study the influence of NPK on yields. The treatments were sulphate of ammonia at 400 lb. and 800 lb. per acre and double superphosphate and muriate of potash both at levels of 100 lb. and 200 lb. per acre.

The trial will continue over four crops. The first crop was harvested eight months after planting and continued for two months. The three following crops will be harvested at intervals of six months with a two-months harvesting period for each. The yield results based on a 1 ft. x 2 ft. spacing using the variety Cambridge Early Pine are shown in Table 7.

Table 7—Strawberry Fertilizer Trial
Summary of Yield Results

Mean Yields ..	0	N1	N2	P1	P2	K1	K2	Mean
lb./acre ..	2,224	2,318	1,742	2,318	2,452	1,554	2,452	2,156

No information of any value came out of this experiment. The yields are well below average for strawberries in Kenya, more especially because the land was straight out of forest. (4) (5.)

Costing/Cropping Trial, Molo

The trial, which is of an observational nature, consists of six single plots of one-twentieth acre each, was planted in July, 1958, to study the economics of the crop and also to find out at what period of the year the variety Cambridge Early Pine will give the best yield.

Three crops are to be taken over a three-year period. The first crop was taken eight months after planting, and harvesting continued for two months. Thereafter cropping will be carried out once yearly over a two-month period. Each plot is being cropped over six different periods to enable determination of yields throughout the year. A basic dressing of FYM at the rate of 40 tons per acre was applied before planting. The first crop results are shown in Table 8.

TABLE 8—COSTING/CROPPING TRIAL
FIRST CROP RESULTS

Cropping Period	lb./acre	Rainfall/inches
1–8–58 to 1–10–58	1,970	13·30
1–10–58 to 1–12–58 ..	5,005	5·09
1–12–58 to 1–2–59	4,075	6·48
1–2–59 to 1–4–59	6,660	5·38
1–4–59 to 1–6–59	10,360	11·51
1–6–59 to 1–8–59	4,080	5·13

The first year's results indicate very strongly that the April/June cropping period produces the heaviest yield of the year. The period coincides with the beginning of the long rains season. The lowest yield coincides with the end of the rains and the period of overcast, cold weather. (4) (5.)

Strawberry Breeding, Molo

Strawberry breeding has been continued by the mass selection of seedlings. Of the original six seedling selections now in their second year, as splits, three of the selections have had to be abandoned due to lack of vigour, poor fruit flavour, small size and leaf spot disease.

On advice from strawberry breeding authorities in Britain and the United States a system of controlled crossing where both parents are known has been introduced. Seeds from 29 various crosses have also been received from Britain and the United States and these contributions should help to speed up the breeding programme very considerably. Seeds of *Fragaria vesca* have been received from Scotland and the resulting plants will be used as virus indicators. (4) (5.)

Shank's Blackberry, Molo

Plants under a netting cage have produced yields at the rate of 13.72 lb. per plant or 19,992 lb. per acre per year over the past two years when spaced at a distance of 3 ft. between plants and 10 ft. between rows. The fruit is likely to have a commercial future where it can be grown close to a market or cannery. (4) (5.)

Cape Gooseberry, Molo

Small scale exports continued satisfactorily. A commercial planting has shown that heavy yields of large sized fruit can be obtained at Molo, but during the wetter seasons of the year considerable losses can occur due to a fungus disorder.

The yields from FYM at 10 tons and 20 tons per acre shown in Table 9 indicate that little is to be achieved by using the higher rate.

TABLE 9

Treatments tons/acre	Yield lb./acre	Yield plant/lb.
FYM 10	14,979	2·76
FYM 20	15,340	2·95

Normally the Cape Gooseberry requires very little in the way of fertilizers or manure, but since the export market demands a fruit of 5 grms. weight and over the FYM was used to boost fruit size. Of the total fruit harvested 33 per cent were of 5 grms. weight or over. The remainder ranged from 3-5 grms. in weight. Recent pruning experiments tend to indicate that pruning is more likely to influence fruit size than manuring. (4) (5.)

Raspberry, Molo

Treatment of raspberries with gibberellic acid and with a combination of indolyl-acetic acid and gibberellic acid has shown that stunted growth of the canes caused by lack of winter chilling and short days can be partly overcome. It remains to be seen whether an increase in yield will result.

On a vlei soil, treatment has been similar and the growth rate showed an increase of 5.6 in. per month. At a later stage indolyl-acetic acid at 100 p.p.m. was used in conjunction with the gibberellic and the growth rate was increased to 7.6 in. per month. (4) (5.)

Youngberry, Molo

Plants are growing in cages on two soil types. One type is of red forest soil and the other is a ridged, grey, ground water vlei soil. Plants on the vlei soil are more vigorous than on the red soil but yields are about the same as on the red soil.

The yield over a 3½-months period on the vlei soil was at the rate of 1.54 lb. per plant or 1,667 lb. per acre, and on the red soil the yield per plant over the same period was 1.61 lb. or 1,753 lb. per acre. (4) (5.)

Passion Fruit

The export of passion fruit, *P. edulis,* is now established. The main supplies were produced by African growers in Machakos District, and were packed by the Horticultural Co-operative Union Ltd. After deduction of all expenses the fruit realized prices up to Sh. 1/84 per dozen. A considerable extension of the acreage in Machakos has been planned in 1960 for juice production.

Tomatoes

Tomato Spraying Experiment, Thika

Three proprietary fungicides containing cuprous oxide, zineb and captan in dispersible powder formulations were tested for their efficiency in controlling tomato blight (*P. infestans*). The effect of the materials was compared using air-blast and high volume knapsack method of application at weekly and fortnightly intervals.

Tomatoes variety Pearson were direct sown on 6th May, 1959, at a double row spacing of 6 ft. and 3 ft. x 2 ft. The design was randomized block with four replicates each of 1/45th acre containing 110 plants. Overhead irrigation was applied, at approximately 1½ in. each application, whenever considered necessary. In total the plants received 29.84 in., i.e. rainfall 13.48 in., irrigation 16.36 in.

Spray treatments were started on 5th June, 1959, when the first true leaves were beginning to develop, and the final application was made on 9th November, 1959. On average the volume of spray applied by airblast was 10 gallons per acre and by high volume 25 gallons per acre. As soon as the first fruit trusses were forming, D.D.T. was applied at fortnightly intervals for the control of tomato worm by adding the insecticide to the spray treatments—the control plots receiving the D.D.T. separately.

During the latter part of August, "blight" spread rapidly over the unsprayed plots and an estimate of the percentage defoliation caused by this disease was made on 17th September, 1959. Harvesting of the fruits at the canning stage of ripeness began on 31st August, 1959, and finished on 9th November, 1959. It was very noticeable that the number of sun-scorched fruits increased in proportion to the loss of foliage due to "blight" attack. Yields of fruit free from blight and sun-scorch were recorded from 30 plants in the centre of each plot. The results are given in Table 10.

TABLE 10

Treatment	Per cent Concentration	Method of Application	Mean Per cent Defoliation per Plot		Mean Yield Tons/acre	
			7 days spray intervals	14 days spray intervals	7 days spray intervals	14 days spray intervals
Cuprous oxide (50%cu.) ..	5·0	Airblast	9·00	21·25	20·0	8·9
Zineb (76%) ..	2·0	Airblast	7·75	42·25	18·2	5·5
Captan (50%) ..	2·5	Airblast	12·50	28·75	16·3	11·8
Cuprous oxide (50%cu.) ..	0·5	High volume	37·50	65·00	5·3	2·1
Zineb (76%) ..	0·2	High volume	26·25	60·00	8·7	3·8
Captan (50%) ..	0·25	High volume	28·75	46·25	7·0	4·2
Unsprayed control			80·00		0·8	

The experiment revealed that there was no significant difference between the effects of cuprous oxide, zineb and captan in increasing yield of fruit, although all three materials greatly increased the yield compared with plots which were unsprayed. The yield on those plots which received the materials by airblasting was significantly greater than on those plots which received high volume spraying, but this may be accounted for by the fact that the amount of compound applied per unit area was approximately four times greater on the plots sprayed by airblasting.

Spraying every seven days gave a significantly greater yield than spraying fortnightly, and this effect was greater on plots sprayed with the airblast than on those plots sprayed with the high volume knapsack. This difference may also be the result of the greater amount of material applied by airblasting.

A trial, complementary to that described above, was carried out to determine the critical periods during which fungicidal sprays were necessary. The results clearly showed the importance of weekly sprays during July and August which coincided with the overcast and misty weather conditions normally experienced during that time of the year. (2) (3.)

Other Vegetables

Asparagus, Thika

At Thika the second harvest of asparagus produced a high percentage of unsaleable spears. The characteristics were an early development of side shoots, a twisting and distortion of growth, and the tip of the spear, instead of being tight, opened prematurely. In severe cases, death of the plant occurred, and in one trial 50 per cent of the crowns have died. An observational trial was laid down to find out whether irrigation or mulch would reduce these symptoms.

On 21st August the old fern was cut down and the asparagus reridged. A grass mulch was applied on alternate plots, of approximately 1/13th acre. During the period of cutting overhead irrigation was applied to one-half the area. In total the irrigated plots received 12.16 in. (rainfall 1.29 in., irrigation 10.87 in.). Cutting commenced on 1st October and continued until 20th November. The spears were trimmed to 6 in. length and then graded according to the diameter measured 1 in. from the base of the spear. Grade I, $\frac{1}{2}$ in. diameter and above; Grade II, $\frac{3}{8}$ in.-$\frac{1}{2}$ in. diameter. Finally a count was made of the number of good quality spears and those exhibiting abnormal characteristics. The yield results and the percentage of good quality spears in each treatment is given in Table 11.

Table 11

Treatment	Mean Yield in lb./acre			Mean Per cent Good Quality Spears		
	Grade I	Grade II	Total	Grade I	Grade II	Total
Mulch	147	99	246	49·9	65·6	57·7
Irrigation	917	169	1,086	69·1	70·2	69·7
Mulch and Irrigation ..	411	156	567	68·9	73·1	71·0
Control	176	118	294	52·7	59·7	56·2

Irrigation greatly increased the yield and slightly increased the percentage of good quality spears. Mulch reduced the soil temperature from a mean of 82.6 deg. F. to 74.7 deg. F. taken daily at 3 p.m. 3 in. below the soil surface, but it did not have any noticeable effect on the reduction of abnormal spears. Mulch depressed the yields both in the irrigated and unirrigated plots. From this observational trial it is clear that there is some other fundamental reason for the abnormality of the spears, and further work is required to discover the cause. Until this is known, growers in this climatic zone are advised not to plant a large acreage of asparagus. (2) (3.)

Asparagus Monthly Cutting Trial, Molo

The third-year yield results show a marked fall-off over the second-year yields. (*See* the 1958 Annual Report, Vol. II, for details.) The decrease in yields is due mainly to the dying out of crowns which, over a period of three cropping years, shows a loss of 57 per cent. The yield results from a 1 ft. x 7 ft. spacing are shown in Table 12.

TABLE 12—MONTHLY CUTTING TRIAL

THIRD-YEAR RESULTS

Treatment	Yield lb./acre	Mean soil Temp. 1ft. °F.	Mean air Temp. °F.	Rainfall inches
May	440·22	64·9	57·4	4·35
June	276·00	65·6	56·3	5·07
July	85·56	62·6	55·5	3·47
August	166·98	62·4	54·7	6·83
September	503·70	63·8	56·2	6·57
October	278·06	68·7	56·8	2·66
November	193·20	64·8	56·8	4·43
December	373·98	63·8	57·5	1·43
January	667·28**	64·9	57·2	2·15
February	810·06	66·1	58·0	0·85
March	833·20**	64·8	58·9	4·45
April	674·06**	62·8	57·9	4·81
Means	446·36	64·1	56·9	4·50

(** Significant at P = 0.01)

From the previous year's results the indications were that soil temperatures influenced yields very considerably, but this factor is not nearly so evident in the present yields. The October yield figures compared with the March figures, for example, show no real evidence that high soil temperatures increase yields. (4) (5.)

ASPARAGUS FERTILIZER TRIAL, MOLO

This trial, which is of duplicate block design, was planted in May, 1957, to compare the influence of fertilizers with FYM on yields. A basic application of 1 *debe* of FYM and 8 oz. of triple superphosphate per 6 ft. of planting furrow was made at the time of planting. The experimental treatments were as follows:—

(*a*) FYM at 1 *debe* per 6 ft. of row annually.

(*b*) Sulphate of ammonia at 400 lb. plus 400 lb. single superphosphate plus 200 lb. sulphate of potash per acre.

(*c*) Sulphate of ammonia at 400 lb. per acre.

The first crop results from a 1 ft. x 7 ft. spacing is shown in Table 13.

TABLE 13—FERTILIZER TRIAL

SUMMARY OF RESULTS

Mean yield	FYM	NPK	N	Mean
lb./acre	728*	496	567	597

(* Significant at P = 0.05)

The yields are considered to be very low in this trial. Usually the first crop at Molo tends to be the highest because thereafter crown die-out commences with subsequent lowering of the yields. (4) (5.)

Asparagus Spacing and Cutting Trial, Molo

This trial, which was an observational one, was designed to compare two different spacings and one cutting a year with two cuttings a year. The spacings were 1 ft. x 7 ft. and 1½ ft. x 4 ft. The cuttings were made during April and September and have now reached their fifth year.

The yield results are shown in Table 14.

Table 14—Spacing and Cutting Trial

Spacing	Year	One cutting per year lb./acre	Two cuttings per year lb./acre	No. crowns planted per acre	Per cent crowns surviving 1 cut/yr.	2 cuts/yr.
1 ft. x 7 ft. ..	1955	836	1,818	6,223		
1 ft. x 7 ft. ..	1956	1,862	2,464	6,223		
1 ft. x 7 ft. ..	1957	2,128	2,576	6,223		
1 ft. x 7 ft. ..	1958	729*	Nil	6,223		
1 ft. x 7 ft. ..	1959	491	429	6,223	38·0	64·0
1½ ft. x 4 ft. ..	1955	1,089	1,696	7,290		
1½ ft. x 4 ft. ..	1956	1,770	2,458	7,290		
1½ ft. x 4 ft. ..	1957	2,416	2,672	7,290		
1½ ft. x 4 ft. ..	1958	903*	Nil	7,290		
1½ ft. x 4 ft. ..	1959	469	305	7,290	44·0	38·0

* The 1958 yields represent only one cutting which occurred in April.

The total yield and also the mean yields per year are shown in Table 15.

Table 15—Mean Yield in Lb./Acre

Spacing	Totals		Means over 4 Years	
	1 cut	2 cuts	1 cut	2 cuts
1 ft. x 7 ft. ..	5,317	7,287	1,329	1,822
1½ ft. x 4 ft...	5,744	7,131	1,438	1,783

The results strongly indicate that two cuttings a year increase the yields of asparagus and that crown die-out is unlikely to be greater when two cuttings a year are made. Nothing would appear to be gained in the way of yield by the closer spacing.

Results from this trial also indicate that the commercial life of asparagus at Molo is unlikely to exceed three years. The 1958 and 1959 crops were almost worthless and could only have been of use in soups. (4) (5.)

ASPARAGUS CROPPING TRIAL, KITALE

An observational 1/9th acre, single plot trial at Kitale sub-station was put down to find out whether asparagus would prove economic in that area on a light sandy loam soil. Cropping has been carried out once yearly over the past four years, and the yield results based on a 1 ft. x 7 ft. spacing are as follows:—

Crop Year	lb./acre	Cutting Period weeks
1956	335	3
1957	1,456	8
1958	3,086	8
1959	2,169	8

The average annual yield at Kitale is 1,761 lb. for one cutting a year, which is about the same as in the Spacing and Cutting Trial at Molo for two cuttings a year. There is also an indication that crowns do not die out as rapidly at Kitale as at Molo. The mean soil temperature at Kitale during the cutting season September/October, 1959, was 71.7 deg. F. at a depth of 1 ft. (4) (5.)

FRENCH BEANS, THIKA

A trial in co-operation with two commercial growers and the Horticultural Co-operative Union Ltd. was successfully carried out on the export by air of fresh French beans to Covent Garden to meet the demand during the winter months from November onwards when they command a very high price.

Weekly sowing of $\frac{1}{4}$-$\frac{1}{2}$ acre of beans, variety Canadian Wonder, were made at each site from the middle of September onwards in order to maintain a continuous supply. Harvesting began nine weeks after sowing and from the third week in November regular consignments were exported three days in each week. They were packed in ventilated cardboard containers lined with tissue paper, each container holding 10 lb. of beans. Success with this crop depends upon the supply of very high quality beans and this entails rigorous grading for size, straightness and maturity and a minimum delay of 24 hours, from the time of harvesting to departure by air from Nairobi.

At the Horticultural Research Station, Thika, a total of 4,957 lb. of beans were harvested from one area, of which 3,630 lb. were selected for export. The net return to the grower, after freight, commission and handling charges were deducted, averaged Sh. 1.097 per lb., giving a total net return of Sh. 2,886/20 per acre. The following was the approximate cost of production for one acre:—

	Sh.	*cts.*
Land Preparation	120	00
Manure and Fertilizer	300	00
Insecticidal Seed Dressing	6	45
Seed	115	00
Packing Materials	312	45
Labour	354	60
Irrigation equivalent to 17″ Rainfall	102	00
	*Sh.*1,310	50

This left a profit of Sh. 1,575/70 per acre from which transport costs must be deducted. At Thika this amounted to Sh. 907/50 if total charges were costed against this one crop and gave a final profit of Sh. 668/20 per acre. It is clear

that production must be within a reasonable distance of Nairobi Airport for economical transport, and to ensure that the product arrives in the freshest possible condition.

The variety Canadian Wonder is by no means ideal for this purpose because it quickly becomes over mature. It was used because a flat podded variety was required by the market, and no other was available at the time. (2) (3.)

Onions

The varieties Bombay Red and Bellary, a new variety from India, were compared on an observational basis at Perkerra and Mwea. Small plots of Bellary were also planted at other sites. The indications are that Bellary is suited to the Kenya climate and will produce yields comparable with Bombay Red. Bellary is very heterogenous and several types are being selected from it for seed production. (2) (5) (8) (7.)

Onion Seed Production, Mwea

Initial success has been obtained with seed production of Bombay Red. Selected bulbs were planted in the long rains, and gave a mean yield at the rate of 111 lb. per acre of clean seed. Bulbs at the rate of one ton per acre were also harvested from this trial. (2) (8.)

Potatoes, Molo

A large number of potato varieties are being grown in isolation for seed production, including American blight resistant and blight immune varieties. The American varieties are proving much more vigorous and free flowering than those of Dutch and United Kingdom origin. (4.)

Potato Fertilizer Trial, Molo

This trial was put down towards the end of the long rains to study the influence of fertilizers on yield. The design was a 2^4 factorial and the variety used was E52 spaced at 1 ft. x 2½ ft. The treatments were N as sulphate of ammonia, P as double superphosphate and K as muriate of potash, all at 1 cwt. per acre, with D as FYM at 10 tons per acre. Planting was carried out on 27th July and the crop was harvested on 23rd November when the haulms had almost completely died off. The summary of yield results is shown in Table 16.

Table 16—Means of Two Plots

Treatments	Tons/acre Total	Tons/acre Ware	Treatments	Tons/acre Total	Tons/acre Ware
(1)	8·98	7·30	N	7·43	6·55
P	11·14	8·26	K	7·70	6·85
D	9·90	8·65	NP	8·64	7·57
NK	8·31	6·57	ND	11·50	9·84
PK	11·90	9·73	PD	9·32	7·78
KD	11·74	9·46	NPK	10·45	9·20
NPD	9·37	7·66	NKD	11·14	9·00
PKD	9·40	7·78	NPKD ..	10·87	9·62

Means: Tons/acre Total — 9.86
Tons/acre Ware — 8.24

There are no significant differences in yield between the treatments. (4) (5.)

Miscellaneous Crops

MUSHROOMS, MOLO

Work on this crop started in July. The compost being tested is a synthetic one based on wheat straw using activators as recommended by the Mushroom Research Association of Great Britain. The yield so far obtained is promising and when complete is expected to reach the 2-3 lb. per sq. ft. production which is obtained commercially in Britain. (4.)

HOPS, MOLO

Testing of seedlings continues but as yet shows no promise. Gibberellic acid has been used in an attempt to stimulate growth and has also been used in conjunction with indolyl-acetic acid, but though growth has been stimulated a plant never gets beyond a height of 18 in. (4.)

DIOSCOREA, MOLO

This crop was introduced during the early part of the year. The plant produces diosgenin from which cortisone and other drugs are produced and is being grown in co-operation with Messrs. Boots Ltd. Although the plants have made growth they appear to lack vigour. Assessment of the drug content and yield potential will be made early next year. The results will then determine whether the crop should continue to be grown at Molo or not. (4.)

Publications

Jackson, T. H.—Tropical Fruit Salad for London. *E.A. Farmer and Planter,* Vol. 3, No. 12, September, 1959.

Attenburrow, D. C.—Cultivation of Bananas. *E.A. Farmer and Planter,* Vol. 3, No. 4, June, 1959.

Since March, monthly notes on subjects of topical interest to horticultural growers, submitted by the Horticultural Research Stations at Thika and Molo, have been included in the Monthly Market Review distributed by the Horticultural Co-operative Union Ltd., Nairobi.

References

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T. H. JACKSON,
Senior Horticultural Research Officer.

APPENDIX A

Horticultural Produce—Imports

Variety	Country of Origin	No. Pkges.	Value
			Sh.
Apples ..	U.K.	1,080	53,400
	S.A.	26,498	787,387
	Italy	27,179	925,042
	Australia	14,384	519,874
Pears ..	Italy	5,871	234,134
	S.A.	1,610	48,941
	Australia	110	4,650
	U.K.	20	500
Grapes ..	Italy	3,353	99,000
	Spain	9,869	827,407
	Portugal	1,500	57,847
	S.A.	26,516	368,663
	Australia	1,468	78,163
Citrus ..	S.A.	8,240	326,577
	Israel	4,181	156,430
Peaches ..	S.A.	3,900	45,000
	Italy	1,303	66,702
Plums ..	S.A.	1,300	15,000
Melons ..	S.A.	1,800	41,911
	Israel	2,555	102,287
	Spain	384	33,675
	Portugal	200	11,144
	Italy	350	12,000
Pomegranates	Spain	871	46,454
	Israel	236	6,164
Onions ..	Egypt and Lebanon	16,550	241,361
	S.A.	943	8,355
	India	6,628	95,680
	Tanganyika	225	3,400
	Total ..		5,217,148

Imports of Fruit Trees and Other Plants

Variety	Country of Origin	No. Pkges.	Value
			Sh.
Fruit Trees ..	S.A.	426	80,336
Other Plants	U.K.	5	1,052
	Ireland	1	160
	Honolulu	1	5
	Holland	1	526
	S.A.	1	240
	Total ..		82,319

ANNUAL REPORT OF THE SENIOR PYRETHRUM OFFICER, 1959

1. Meteorological

In a more comprehensive and detailed report to be published by the Pyrethrum Board of Kenya meteorological data for the individual pyrethrum research centres will be recorded.

As was hoped, a reasonably long period of dry weather between the end of the 1958 rains and the beginning of the new season in 1959 had a favourable effect on soil nitrification and encouraged vigorous flowering of all established pyrethrum. Rather lower mean temperatures than those prevailing in 1957 and 1958 resulted in good pyrethrins contents; the average for the Colony was 1.54 per cent, 0.19 per cent higher than in the preceding year. Flower deliveries to the Pyrethrum Board amounted to 11,110,716 lb., an increase of 2,545,429 lb. over the previous year. This increase is, of course, not entirely due to climatic factors but also to a larger acreage established during 1958, improved cultivation methods and better varieties grown. The rains, although ample for flower production, were a little sporadic at times (June, July, August) so that it was difficult in certain areas to establish new plantings. However, where these succeeded they yielded exceptionally well. The slightly colder temperatures seemed to have reduced the incidence of thrips which became more common only towards the end of the year when the soil began to warm up. *Ramularia bellunensis* and the physiological form of bud disease caused certain losses chiefly during the rainy and cloudy months of August and November.

2. Experimental Work

(*a*) Fertilizer Trials

Altogether 14 field experiments in different areas of the pyrethrum-growing districts were maintained. The results in general indicated a phosphorus demand in the more reddish and leached soils especially at higher altitudes. The use of phosphatic fertilizers should be further encouraged.

On the Grassland Station, Marindas (9,100 ft.), the following results were recorded during the last two seasons:—

(*Yields in lb./acre dry flowers*)

	1958/59	1959/60
Control (no fertilizer)	1,042	444
200 lb./acre Triple Supers.	1,337**	769**
450 lb./acre Basic Slag	1,376**	697**
450 lb./acre Kenaf	1,317**	651**

** Significant at P=0.01.

While all types of phosphates have produced greatly increased yields in both seasons, no difference exists between the efficacy of the various fertilizers.

In 1958 two identical trials were planted on poorish red soils at Mau Summit (8,300 ft.) and Upper Gilgil (8,700 ft.) respectively. In the second (1959/60) season they yielded as follows:—

	James, Mau Summit	Roller, Gilgil
Main Effects and Interactions		
(1)	869	459
P	+238**	+262**
K	+14	−52
PK	+94*	−55
Ca	+108*	+57*
PCa	+28	−36
KCa	−23	+18
PKCa	−85*	+31

** Significant at P=0.01.

* Significant at P=0.05.

(P=200 lb./acre Triple Supers; K=100 lb./acre Muriate of Potash; Ca=3 tons/acre Lime.)

(*b*) Rotation Trials

On the Grassland Station a trial was started in 1957 to test the effect, if any, of various green crops planted for one year between two crops of pyrethrum. In 1958 the second lot of pyrethrum was established which showed no reaction to any of the green manure treatments. In the second, 1959/60, season again no significant differences as a result of the various rotations were recorded. The pyrethrum plots were split however for fertilizing with triple superphosphate versus no fertilizer and this produced remarkable results (in lb./acre dry flowers):—

	1958/59	1959/60
Control (no fertilizer)	376	631
200 lb./acre Triple Supers.	785**	1,099***

** Significant at P=0.01.

*** Significant at P=0.001.

It is not advocated except in special circumstances to interpolate one green crop only between two plantings of pyrethrum. For reasons of the control of certain pests such as root knot eelworm a grass ley should be introduced at some point of rotation.

A large experiment at Ol Joro Orok has now completed its thirteenth season. The object was to find the optimum place for pyrethrum in a balanced rotation. Continuous pyrethrum, replanted every fourth year in the same place, is being compared with crops which are grown in rotation with cereals or grass or both. The grass plots are grazed by sheep. This experiment has so far produced no conclusive results.

(*c*) The Stripping Trial

An experiment laid down at Ol Joro Orok with clone 194 has now completed three seasons. The overall yields were (in lb./acre pyrethrins):—

Stripping down to	Buds	Petals Vertical	Petals Horizontal	Average Time
2 weeks	20·22	45·41	45·01	36·88
3 weeks	32·95	40·06	39·25	37·42
4 weeks	35·31	40·81	40·71	38·94
6 weeks	36·07	34·65	32·27	34·33
Average Picking ..	31·14	40·23	39·31	

Differences required for significance:—

Picking	Time	Picking x Time
P=0·01: 3·06	not	6·11
P=0·05: 2·26	significant	4·51

Stripping down to either vertical or horizontal petals at two-weekly intervals has guaranteed the highest yields in pyrethrins per acre. The physical analyses of the picking samples have proved that the portion of overblown flowers increases to well over 10 per cent if stripping is left for four weeks or longer, thus depressing the total yield. The picking of buds should be avoided.

3. Plant Breeding

An all-out effort has been made to step up the production of seed from improved varieties. This has been on the whole successful, but erratic rains, especially in the Ol Joro Orok area, from June to August interfered with the establishment of some of the seed fields. Production of the following varieties (hybrids) was either begun or enlarged: C.43, C.45, C.47, C.92, M.9, M.11, M.15, M.31 and M.34, while the existing fields for 100.A, Subukia, the two "sugar beet" breeding systems, C.60, C.79 and M.21 and O.4 were kept at their existing level. The seed delivered to the Pyrethrum Board from all these areas amounted to 5,234 lb., i.e. 3,202 lb. more than in 1958.

Work on single-plant selections had to be slightly restricted and only 141 new selections were made which gave a total of 667 under observation on the various research stations. 31 isolated plots were maintained for the production of new hybrids and 12 large isolation fields at Molo (eight) and Subukia (four) for the continuation of the "sugar beet" breeding systems. Interesting results were forthcoming from a polycross made between the Polhill variety and a large number of tested clones with an upright growth habit. Some of the lines will be pursued further and it is hoped to issue a suitable variety for the higher and colder altitudes which combines the outstanding qualities of Polhill with a more upright growth.

In 22 yield trials located over a wide range of the pyrethrum-growing areas the following new hybrids have given an outstanding performance: M.41, M.42, M.43, M.44, M.47, M.49 and O.17. Their parent clones are already being bulked up and will be transferred into seed production fields during the coming season.

U. KROLL,
Senior Pyrethrum Officer.

ANNUAL REPORT OF THE OFFICER IN CHARGE SISAL RESEARCH, 1959

Meteorological

RAINFALL AT THE SISAL RESEARCH STATION, THIKA

	1959	Average previous 18 years
January	1·98″ in 6 days	1·21″ in 3·2 days
February	0·24″ in 1 day	1·51″ in 2·8 days
March	2·39″ in 8 days	3·40″ in 7·2 days
April	5·79″ in 11 days	8·65″ in 15·4 days
May	9·05″ in 17 days	5·05″ in 11·5 days
June	0·03″ in 1 day	1·04″ in 5·1 days
July	0·69″ in 3 days	0·60″ in 3·7 days
August	0·59″ in 7 days	0·65″ in 4·4 days
September	0·07″ in 1 day	0·65″ in 3·2 days
October	0·94″ in 4 days	1·74″ in 5·1 days
November	10·05″ in 19 days	5·42″ in 14·3 days
December	1·32″ in 3 days	3·19″ in 9·3 days
Total..	33·14″ in 81 days	33·11″ in 85·2 days

The average rainfall for the 19 years recorded at the Station 1941-1959 amounts to 33.11 in. in 84.3 days.

SALE OF FIBRE

41,678 lb. of fibre, 710 lb. of tow and 2,128 lb. flume tow were produced at the Station during the year. It was sold locally for approximately £1,368, which was paid directly to the Kenya Sisal Board.

Investigational Work in Progress

NURSERY TRIALS

A small but significant response was obtained in the third cycle of the irrigated nursery trial, whereas no responses to irrigation had been obtained in the two previous cycles. This result may be due partly to higher rates of water application and also to the fact that the application of the water was done over a longer period of time. Neither the effects of sisal waste applications, nor of nitrogen applications were enhanced by irrigation. The trial continues in its fourth cycle.

Responses to farmyard manure, at rates similar to sisal waste, were similar to responses from sisal waste although the evenness of the plant size was not good. The addition of nitrogen to either farmyard manure or waste increased the plant size to a smaller extent than the addition of lime in this trial. This is also the first trial in which a beneficial response to lime has been obtained, a point which will be studied further in relation to the soil.

A new nursery trial was planted in June, 1959, to compare, singly and in combination, the effects of P, K and S on a soil where analysis had indicated a shortage of these elements.

Two old nursery trials running for the fourth and sixth cycle were lifted and replanted during the year. No new information became available apart from the fact that the soil can still produce a good-size plant after six to nine years of nursery on the same land.

Plant Management Trials

Three of the five external spacing and cutting trials were cut out during the year. A complete report of each trial from planting to final cut is made to the estates where the trials were in progress and a general report on these trials will be published in due course. The recommendations on planting and cutting given to estates in the various districts during the last four to five years are mainly based on these trials.

These trials have been reported on in detail in previous annual reports and only the factors which are common to all the trials will be dealt with this year. As the longevity of the trials is about the same, the factor of most interest will be the quantity of unbrushed fibre per acre. This will be under comparison below:—

Spacing

With exception of the trial on black cotton soil in Ruiru where the double row was slightly better than the two single rows, the other four trials all to a smaller or larger degree showed an increase in fibre yield from the 11 ft. row spacing. The reason for this must be attributed to the wider spacings between the plants in a row within the various populations, rather than the actual spacing of 11 ft. between the rows. The importance of having room between the plants in a row to encourage a longer leaf and speedier growth is further emphasized in the D/8 double versus single row trial reported on below.

Population

Increases in yield of fibre have been seen in all trials when the population per acre was increased. The increases follow the law of diminishing returns in three trials, and can be explained as follows, with totals in brackets:—

	D/4 Hoey's Bridge	D/5 Kampi ya Moto	D/6 Thika Red Soil
Fibre from 1,200 plants	5·57	3·37	5·16
From next 400 (1,600 plants) ..	1·32 (6·89)	0·87 (4·24)	1·34 (6·50)
From next 400 (2,000 plants) ..	0·66 (7·55)	0·56 (4·80)	0·88 (7·38)

The increases due to the last 400 plants is smaller than from the previous 400 plants as would be expected, but the increases are still so big that it is worth while planting the extra 400 plants per acre. There is thus no indication that the recommendation of 2,000 plants per acre in these localities is exceeding the optimum number of plants per acre. In the Hoey's Bridge and Kampi ya Moto areas an increase in fibre due to a further increase in number of plants per acre is likely to be so small as to be of no interest, but on the fertile red soils in the Thika area one may feel justified in recommending a population of even more than 2,000 plants per acre, if that is feasible in field practice, as even a substantial reduction in yield from a further 400 plants per acre would constitute considerable increase in fibre yield.

In two trials the figures would indicate that the optimum number of plants per acre has not been reached with 2,000 plants per acre:—

	D/3 Ruiru Black Cotton Soil	D/7 Kibwezi
Fibre from 1,200 plants	3·24	4·28
From next 400 (1,600 plants)	0·32 (3·56)	0·78 (5·06)
From next 400 (2,000 plants)	0·56 (4·12)	1·10 (6·16)

The Ruiru trial grew very unevenly and although the law of diminishing returns does not appear to apply one would be loath to recommend more than 2,000 plants per acre in this area. The increase in fibre yield in the high populations is mainly due to the longer life of each plant.

In Kibwezi there is, however, reason to believe that populations over 2,000 plants per acre would be advisable so as to increase the fibre yield per acre. Whether this can be done conducive with other field operations is problematic, but it is clear that populations less than 2,000 plants can only mean a substantial reduction in the potential yields of fibre.

To get 2,000 plants planted per acre, and still maintain reasonable access to the field, means that one will have to plant double rows. One often hears growers say that plants in double rows develop slower and produce fewer leaves than in single rows. This is not quite correct. One employs double rows so as to get a high population and invidual plants at high populations develop slower and each plant produces fewer leaves than in the smaller population, hence it is the population and not the double row which is the cause of the slower growth and smaller leaf number. That this feature is closely related to population can be expressed as follows:—

	Average Number of Leaves Cut Per Plant				
	D/3	D/4	D/5	D/6	D/7
From 1,200 plants per acre	141	212	157	198	149
From 1,600 plants per acre	132 (−9)	205 (−7)	154 (−3)	193 (−5)	140 (−9)
From 2,000 plants per acre	126 (−6)	190 (−15)	144 (−10)	179 (−14)	139 (−1)

In all cases the number of leaves cut per plant has been progressively smaller as the population was increased. As the main interest is in the yields of fibre this factor is of minor concern and should only be of academic interest to the growers.

Development at First Cut

In all the five external trials cutting commenced at three levels unrelated to time (i.e. age of plants) but related to the number of leaves grown per plant since planting. Cutting commenced after an average of 100, 125 or 150 leaves had been produced.

With exception of the trial at Hoey's Bridge, there were clear indications in all trials that a first cut, delayed till the plants have grown 150 leaves, resulted in fewer leaves being cut per plant. The leaves cut off have however been longer and a smaller amount of leaves has been needed per ton of fibre produced, but it is doubtful whether the smaller production costs are offset against the smaller output of fibre.

There is little difference in fibre yields between the plants where cutting commenced at leaf stage 100 and leaf stage 125. There is a tendency for the earliest first cut to induce a higher leaf number and for more leaves to be cut off per plant, but as this is not reflected in higher fibre yields it means that the earliest first cut also induced shorter leaves to be grown and more leaves to be needed per ton of fibre produced. The recommendation must therefore stand on a compromise of commencing cutting somewhere between leaf count number 100 and 125. An exception to this is the Kibwezi area where in that area, due to the more rapid rate of growth, cutting should not commence later than leaf sequence number 100, as leaves of commercial length are likely to dry up.

Intensity of Cuts

Three levels of cutting intensity were imposed on the five external trials, the cutting intensity being governed by the number of leaves left per plant after each cut and not by the number of leaves cut off. The three levels were: leaving 30, 20 and 10 leaves per plant after each cut.

In the Hoey's Bridge and Kibwezi trials there were definite indications that the fibre yields had been reduced when only 20 or 10 leaves had been left per plant. The indications were not so clear in the other three trials, probably because a strict annual cutting cycle was followed and it is likely that the effects would have been more pronounced if a six-monthly or nine-monthly cutting programme had been introduced. The heavier cuts have induced more leaves to be grown and to be cut off, have delayed poling but have needed more leaves per ton of fibre produced. As the variations in fibre yield are small, there is ample reason for recommending light cuts leaving at least 30 leaves per plant after each cut.

The two trials remaining in Hoey's Bridge and at Kampi ya Moto will be cut out during 1960 bringing to completion this series of trials commenced in 1948.

Double Versus Single Row Trial

The object of this trial is to compare the growth of sisal plants planted in single or double rows with everything else being equal.

Having decided on a certain population of plants per acre, it is important to ascertain whether the plants will grow faster when planted in double rows than when planted in single rows. The advantage of the double row is that with the same population the plants are spaced wider apart in the line.

Two row-spacings of 11 ft. and 13 ft. are tested against three populations of 1,600, 2,000 and 2,400 plants per acre.

The double rows were in all cases formed by planting two lines 3 ft. apart.

A comparison made on yield of unbrushed fibre in tons per acre after seven and a half years looks as follows (numbers in brackets indicating the spacing between the plants in the line):—

	Plants per acre					
	1,600		2,000		2,400	
11′+3′ (double row)	(4′)	5·61	(3′)	5·99	(2′ 6″)	6·11
11′ (single row)	(2′ 6″)	5·07	(2′)	4·01	(1′ 8″)	3·82
13′+3′ (double row)	(3′ 6″)	5·01	(2′ 9″)	4·55	(2′ 3″)	3·79
13′ (single row)	(2′)	4·34	(1′ 9″)	3·79	(1′ 5″)	2·43

The poling percentages, indicating the rate of growth, are closely related to the tonnage of fibre obtained.

In all cases the double rows have yielded their fibre at a rate faster than the single rows and this can only be attributed to the wider distance between the plants in the row. The serious decrease in rate of growth when plant distance is reduced below 2 ft. 6 in. is clearly reflected in the low output of fibre to date.

A D/9 cutting intervals trial was planted during the year to compare numbers of cuts over the cycle varying from the usual six or seven to only one cut.

Cultivation Trials After Planting

Three new trials were planted during the year—

(1) to investigate the effect of various intensities of desuckering versus none;

(2) to investigate the effect of indigenous and introduced grasses on sisal when they are either slashed mechanically or grazed by cattle;

(3) to investigate the effect of various leguminous cover crops on sisal in comparison with indigenous grasses.

Fertilizer Trials

The first fetilizer trial planted at the Sisal Research Station in March, 1950, was cut out during the year.

For lime, phosphate and potassium there are no significant differences in the number of leaves grown per plant or in tonnage of unbrushed fibre obtained per acre. The difference in weight is due to small, but insignificant, variations in the first four to five cuts and the cumulative effect of these variations add up to the final difference.

There is no significant difference in leaf count between the plants receiving no sisal waste and those receiving sisal waste. There is however a highly significant ($P=0.01$) difference in fibre weight, which is due to the longer leaves grown and this difference became apparent from the first cuts. The application of sisal waste not only induced longer leaves to be grown, but they also grew at a more rapid rate, so the fibre yields were obtained earlier. From the records of leaf count and fibre yields it would appear as if the application of sisal waste would be able to reduce the cycle by a couple of years.

The applications of nitrogen as sulphate of ammonia made annually during the first four years at a rate of 388 lb. per acre has significantly ($P=0.01$) increased the number of leaves per plant, which again has been reflected in a significant increase in fibre yield per acre.

Comparing the effect of the interaction between sisal waste and nitrogen on fibre yield and average number of leaves per ton of fibre over the whole cycle we obtain the following results:—

	No waste No nitrogen	Sisal waste	Nitrogen	Sisal waste nitrogen
Tons fibre per acre	5·25	6·12	6·37	6·84
Average No. of leaves per ton fibre	65,600	58,500	57,900	54,400
Total No. of leaves cut per acre ..	344,400	358,000	368,800	372,100

The saving in cost of cutting, transport and decortication of the smaller number of leaves per ton of fibre is a variable which each estate will have to work out. Comparing the two extremes one would imagine that a fair margin of profit would be available for waste and nitrogen applications if over one and a half tons more fibre could be produced for the expense of cutting, transporting and decorticating only about 40,000 more leaves.

The F/5 exploratory fertilizer trial at Kibwezi which was planted in April, 1953, was cut out and completed during the year. It is the fastest growing trial this Station has ever handled and information which is now available from the completed spacing and cutting trial (D/7) in this area indicates that cutting in the fertilizer trial commenced too late and was carried on at too long intervals.

The effects of phosphate and lime applications were negligible and neither influenced the rate of leaves grown nor the final fibre yield.

Nitrogen applications accelerated growth rate, produced a longer leaf, a higher leaf number per plant and an increase in fibre yield.

The interaction between sisal waste and nitrogen as expressed in tons of unbrushed fibre per acre can be seen as follows:—

	No waste	25 tons waste	50 tons waste	100 tons waste
Without nitrogen	5·84	6·24	6·23	5·93
With nitrogen	6·12	6·64	6·64	6·15

In the (F/7) fertilizer rates trial planted at the Station in August, 1954, there is little difference in the variations in leaf growth reported on in last year's report.

In all other fertilizer trials the main beneficial responses are also to applications of sisal waste and/or nitrogen, but significant and lasting responses to phosphate have only been obtained on murrum soils in the Ruiru area.

Hybrids and Variety Trials

The hybrid comparison trial was planted in April, 1952, and poling is general in some of the hybrids under review.

It is clear that hybrids Nos. 1155, 1300, 1317 and 7131 cannot be of much interest due to the low fibre yields and due to the large number of leaves needed to produce one ton of fibre, and the overall picture would not indicate that any

of these hybrids are better than *Agave sisalana*. Hybrids like Nos. 1660 and 6964 will need further investigation, possibl ywith fertilizers, and will be compared with other hybrids in the future.

The ten bulbil plants of hybrid No. 11648 received from the Sisal Research Station, Tanganyika, in April, 1956, are doing well. Variations are great between these ten plants and difference in leaf count to date varies from 90 to 150 leaves per plant. Multiplication of these plants from suckers and rhizomes will commence in 1960. The sucker production has to date been very small. The plants are being manured heavily with sisal waste and nitrogen and are watered in the dry weather to encourage growth in the hope of accelerating the rate of reproduction. This hybrid has given very promising results in Tanganyika and warrants serious study under Kenya conditions.

Herbicide Trials

During the year, the range of experiments with herbicides was extended, particularly with dalapon. The greatest weed problem in Kenya sisal is unquestionably "couch" (*Digitaria scalarum*) and it is for this reason that so much work has been done, and is continuing, with dalapon, which so far has shown the greatest promise as a chemical "couch" control measure.

In 1957 and 1958 the weed control obtained by chemicals was under examination; during the current year their specific action on bulbils in nurseries is being observed. In one trial rates from as low as $\frac{1}{2}$ lb. acid equivalent of three chemicals to high toxic doses of 4 lb. acid equivalent are being applied and careful notes are kept in order to obtain a clear understanding of the behaviour of bulbils subjected to chemical sprays and also the probable dose limits to which they are tolerant. Die-back from the tip thorn in the lower leaves of field sisal due to dalapon applications has been described in previous reports, the phytotoxic effects of these other chemicals on bulbils will apply to a lesser degree, perhaps not at all, on larger sisal plants. The three weedkillers under test are as follows: the butyl Ester of 2,4-D, the Amine salt of 2,4-D and MCPA. In addition, CMU and dalapon are being tested in the same way.

Exploratory work with new herbicides in collaboration with the chemical firms was continued at the Station during the year. This included the use of triazines and the testing of combinations of various grass and soft-weed killers.

K. LERCHE,
Senior Assistant Agricultural Officer.

IRRIGATION INVESTIGATIONS

Irrigation Research Station, Mwea/Tebere/Embu

Weather Conditions

The total rainfall for the year was 25.66 in.: this is the lowest for the four years since recording started at this station. The rainfall was as follows:—

	Inches	Days
January	1·74	7
February	0·37	5
March	1·42	6
April	5·22	10
May	6·11	15
June	0·11	2
July	0·87	5
August	0·78	3
September	0·07	3
October	—	—
November	7·37	14
December	1·60	4
Total	25·66	74

Rainfall intensity, air temperature, evaporation and sunshine records were kept throughout the year.

Rice Varieties

The variety collection which was started in 1956 was continued; seven varieties from U.S.A., four from Nigeria, 15 from Japan, seven from India, three from Austria and one from Surinam were added to the collection. Several of these are upland rices which are being bulked up for trial elsewhere. No variety has yet shown itself to be outstanding enough to justify its ousting Sindano as the standard variety in the area.

Rice Fertilizer and Spacing Experiments

The 3^3 fertilizer and spacing experiment which was started in the long rains of 1958 was continued. The treatments were: three levels of sulphate of ammonia and double superphosphate (0, 1 and 2 cwt./acre), and three spacings 6 in. by 6 in., 9 in. by 9 in. and 12 in. by 12 in. The long rains 1959 crop showed large significant responses to applications of sulphate of ammonia and double superphosphate but showed no difference between the 1 cwt. and 2 cwt. rates of application of either fertilizer. The spacings also differed significantly—the 6 in. by 6 in. spacing giving the higher yield. The results are summarized in Table I:—

Table I—Results of Spacing and Fertilizer Trial: Mean Yields of Dry Paddy in Lbs./Acre

N_0 3,230	N_1 3,519	N_2 3,686
P_0 3,091	P_1 3,657	P_2 3,686
6″ x 6″ 4,039	9″ x 9″ 3,449	12″ x 12″ 2,946

The trial to compare the effect of various forms of phosphatic fertilizer on the yield of rice in the presence and absence of sulphate of ammonia was continued. The rates of application of the various forms of phosphatic fertilizer applied S.R. 1958 were calculated so as to have the same amount of citric soluble P_2O_5 as 1 cwt./acre of double superphosphate. The plots were split for dressings of 0 and 1 cwt./acre of sulphate of ammonia. There was no significant response to or difference between residuals of the phosphate treatments but there was a significant response to sulphate of ammonia applied at 1 cwt./acre. The results are summarized in Table II:—

TABLE II—MEAN YIELD OF DRY PADDY IN LB./ACRE

Nil	3,570	Main plots
Double Superphosphate	3,449	
Hyperphosphate	3,449	
Soda phosphate	3,703	
Basic Slag	3,461	
Uganda Rock phosphate	3,376	
Sulphate of ammonia	3,888	Sub plots
No Sulphate of ammonia	3,114	

WATER REQUIREMENTS OF RICE

Measurement of the amount of water required to grow a crop of Sindano rice has been carried out here intermittently since 1957. The water applied to a quarter-acre field is measured by means of a Kent's "Torrent" meter. The water measured is that required for preplanting operations and the growth of the crop; it does not include the water required for nursery work; since the water is led into the field by metal pipes there is no loss due to seepage in canals. There is no drainage from the field until just before harvest: the water level is merely kept topped up to about 3 in. The results to date indicate that the water requirement of the variety Sindano on the black soils at Mwea is somewhere above 40 in. during the growing season. The results to date are summarized in Table III. The 1958 result was low due to seepage from a fish-pond.

TABLE III

	L.R. '57	S.R. '58	L.R. '59
Total Irrigation	17·00	16·30	29·44
Total Rainfall	22·50	17·10	12·90
Total Water	39·5	33·40	42·34

RICE MECHANIZATION

Further trials of direct sowing of seed were done. This was done with a Ferguson seed drill just prior to the onset of the long rains. The crop germinated well, but latterly growth was uneven and the yields were only about half those of the transplanted rice.

RICE HARVESTING

A special sheafing attachment to fit on a 6-ft. mower was constructed by Messrs. Farm Machinery (Dist.) Ltd., Nairobi, to plans supplied by Massey Harris, Ferguson, England.

This equipment was used to harvest both drilled and transplanted fields and, on the whole, it worked well; it was, of course, necessary to cut around the field by hand first. The sheaves made by this apparatus were found to be more difficult to thresh by hand than were those cut by hand.

Other Crops for the Black Soil

Observation plots on several crops were continued: sorghum, sunflower and chick pea gave moderate yields. A quarter-acre plot of sugar cane yielded 55 tons/acre of cane. The experiments on fish (*Tilapia nigra*) continue under the supervision of the Chief Fisheries Research Officer of the Game Department.

Red Soil Irrigation

Three main methods of irrigation were used on the red soil during the year: these were level contour terraces, inclined furrows and overhead irrigation. The overhead irrigation system is fairly new but has worked well in the onion field and Turkish tobacco nursery; it has the great advantage that little or no levelling of the site is required and there is a more even spread of water than that given by other methods.

Observational work was carried on throughout the year on numerous possible cash crops for the red soil. The most promising crops to date are tomatoes, onions, asparagus, lucerne, sugar cane, melons, cucumbers, chillies and hibiscus. Observation plots of coffee (arabica, robusta and excelsa) and tea have been planted. Some of the coffee has borne its first crop.

Various fruit trees have also been planted, but these are still too young to give much information; the cashew nuts are growing well and have produced one or two fruit.

Hibiscus Cannabinus

Trials on this crop started in 1956 and the yields have generally been poor; it seems, however, that we are gradually acquiring some knowledge of this crop and yields are improving. In a fertilizer and variety trial planted in 1958 and harvested in 1959 a mean yield of 908 lb./acre of dried fibre was obtained: an application of 1 cwt./acre of sulphate of ammonia increased the yield significantly over that of the control; an application of 2 cwt./acre increased the yield still further but not significantly.

The five-ton level of farmyard manure significantly outyielded the control; the 10 ton/acre dressing did not. There were no significant differences between varieties. The results of this trial are summarized in Table IV:—

Table IV—Mean Yields of Dry Fibre in Lb./Acre

N_0	N_1	N_2
736	927	1,061
M_0	M_1	M_2
849	977	899
E.C.R.985	E.C.R.986	Nigeria
913	948	865

Attempts at decorticating hibiscus with the Bell decorticator have not been a great success; it seems that the roller setting is too wide and since this machine is said to be a success in Rhodesia it would seem that our problem is mainly the cultural one of how to grow bigger hibiscus.

Unirrigated Maize Manurial Experiments

These experiments were started in the long rains 1958 to obtain information on the cropping potential of the red soils on rainfall alone.

The manurial experiment was a 3^3 factorial with a single replicate to test the effect on yield of farmyard manure at 0, 5 and 10 tons/acre, sulphate of

ammonia and double superphosphate at 0, 1, and 2 cwt./acre. The farmyard manure and phosphate were applied before planting—the sulphate of ammonia was applied as a top dressing 16 days after planting.

There was a large response to farmyard manure at the 10-ton rate, but not at the five-ton rate. There was a large response to sulphate of ammonia, but the 2 cwt./acre rate did not give a significant increase over the 1 cwt./acre rate.

There was no response to phosphate.

The results are summarized in Table V:—

TABLE V—MEAN YIELD OF GRAIN IN LB./ACRE

N_0 2,188	N_1 3,112	N_2 3,237
P_0 2,758	P_1 2,886	P_2 2,894
M_0 2,607	M_1 2,720	M_2 3,210

J. M. SUTTIE,
Agricultural Research Officer.

Irrigation Scheme, Galole

IRRIGATION TRIAL

A trial was planted at Galole to compare the effects of five different watering programmes on the yields of seed cotton. All treatments were watered at seven to ten-day intervals until flowering and then the following programmes imposed:—

(*a*) Watering was continued until one-third of the crop had set and then stopped.

(*b*) Watering was continued at seven-day intervals until the bolls were nearing maturity.

(*c*) Watering was continued at 14-day intervals until the bolls were nearing maturity.

(*d*) Watering was continued at 21-day intervals until the bolls were nearing maturity.

(*e*) Watering was stopped for three weeks at flowering and then continued at seven-day intervals until maturity.

The variety was U.K.51. The design was randomized blocks of 1/40th-acre plots and the spacing was 3 ft. × 1½ ft. The yields are given in Table VI:—

TABLE VI—YIELD OF SEED COTTON IN LB./ACRE

Treatment	A	B	C	D	E	SE	LSD p=·05
Yield	1,113·8	1,257·1	1,103·9	1,210·0	1,394·6	±126·0	371·9

There were no significant differences between treatments.

M. F. WATSON,
Agricultural Research Officer,
Coast Province.

Irrigation Research Station, Perkerra

The work carried out on the station during 1959 was particularly varied in respect of both crops and livestock. A summary of the yields and progress on each project will serve to indicate the value of each enterprise.

Crops

CITRUS

Of the trees planted in 1955 the following yields were obtained:—

	lb. per tree
Marsh seedless grapefruit	4,917
Seville orange	453
Tahiti lime	735
Washington Navel	22
Eureka lemon	2,660
Villa Franca lemon	2,921

The orchard was beset with such pests as red scale and rust mite.

DATES

The various varieties commenced flowering in October. Difficulty was experienced in pollination in that male plants outnumbered the female, but at the end of the year a considerable number of bunches were forming.

ONIONS

Under the water régime of two inches every ten days, Bombay Red yielded 61 cwt. per acre and Bellary yielded 56.8 cwt. per acre; these yields at a spacing of 43,000 plants per acre.

MAIZE

Eight varieties were compared. Of these the top yielder was Kjaertinge Yellow Rongai selection: 46.4 cwt. per acre. BSA.5 was next at 41 cwt. per acre. As a comparison, White Sorghum yielded only 33 cwt. per acre.

PULSES AND LEGUMES

A great number of these were tried, the most important yielding as follows:—

	Cwt. per acre
Soya bean Congo	5.8
White haricot beans	9.2
Tender green beans	21.7
Stringless ex Uganda	19.3
Canadian Wonder	16.2
Green gram	10.4
Black gram	9.3

Groundnuts produced the poor yield of 6.2 cwt. per acre (shelled).

COFFEE NURSERY

Sixty thousand seedlings and three varieties of coffee were grown under heavy shade for eventual distribution to African areas in the province. These seedlings were rather small at the end of the year.

PASTURE RESEARCH

Two acres of land were prepared for the bulking of grass seeds for the pasture research section, while a further six acres was set aside for a co-operative experiment with E.A.A.F.R.O. to study the water requirements of irrigated Star grass.

Livestock

Beef

In January four steers and eight heifers from Naro Moru were obtained, six of these being placed on irrigated Star grass and six fed Napier grass in a feed lot in the shade. These are cross-bred animals consisting of the offspring of Aberdeen Angus and Hereford bulls. The average gain per day over each group is as follows:—

Outside grazing on Star	0.68 lb. per day
Stall-fed on Napier grass	0.97 lb. per day

In April six Sahiwal cross Boran animals were obtained and these were fed entirely on irrigated Star grass, the average daily gain being 0.86 lb. per day.

In October six local Zebu cattle were obtained and three placed on the feed lot and three grazed outdoors on Star grass. Average daily gains were:—

Star grass	1.1 lb. per day
Stall-fed Napier grass	1.14 lb. per day

Dairy Cattle

Eight Jersey cows were obtained from the Molo Pyrethrum Station and at the end of the year these were only half-way through their lactation, so that yield figures are not available. Both dams and calves, however, were in extremely good condition and provided shade was available at midday these animals did not show undue distress due to the extreme heat.

Sheep

In July 32 head, being a mixed bunch of Corriedale crossed with Masai, and black-faced Persians, were obtained from Eldoret. Lambing commenced in mid-October and at the end of the year 12 lambs had been born.

Two of these lambs at 11 weeks old were sent to the Kenya Meat Commission at Nakuru. Although under weight, these lambs were favourably reported on by the grader.

O. T. ROBERTS,
for Assistant Director of Agriculture,
Rift Valley Province.

ANNUAL REPORT OF THE OFFICER IN CHARGE AGRICULTURAL MACHINERY RESEARCH AND DEVELOPMENT, 1959

As the post was only established at the beginning of 1959, most of the year has been spent in building up facilities and in general investigation into machinery problems so that a programme of work could be laid down.

Soil Conservation Machinery

Trials were carried out to compare the cost of making broad-based terraces, V-terraces and cut-off ditches with three different types of equipment:

(1) Crawler tractor with towed terracer.

(2) Motor grader.

(3) Four-wheeled drive wheeled tractor with towed terracer.

The running costs were estimated by allowing for complete write-off after 10,000 hours for the heavy machines, and 8,000 hours for the wheeled tractor, and assuming 100 per cent of original cost in spares and repairs. To this was added labour at Sh. 2/50 per operator per hour. Table I summarizes the results. The high cost of the motor grader on the broad-based terrace was due to the operator not having used this type of machine on a broad-based terrace before, and experience elsewhere has shown that the motor grader is capable of putting up a broad-based terrace in the same number of runs as a crawler tractor. The motor grader appears to be cheaper than the crawler tractor under good conditions, but will not always work in wet conditions. It is easier to move from farm to farm, but cannot be used for dam construction or bulldozing. The four-wheeled drive tractor is as cheap as big machines for V-terraces, but not on cut-offs or broad-based terraces.

TABLE I

	1	2	3	4	5	6	7	8
Total Working Time (mins. and secs.)	32′ 8″	86′ 12″	47′ 35″	77′ 59″	81′ 47″	49′ 46:	86′ 21″	40′ 5″
Total Turning Time (mins. and secs.)	7′ 45″	18′ 44″	7′ 2″	19′ 23″	46′ 53″	10′ 29″	33′ 33″	6′ 0″
Total Blockage or Breakdown	0	11′ 30″	0	0	25′ 45″	0	16′ 20″	0
Total Terracing Time (mins. and secs.)	39′ 53″	96′ 34″	54′ 37″	97′ 22″	154′ 25″	60′ 15″	136′ 14″	46′ 5″
Number of Runs	7	14	7	22	21	12	20	7
Working Time/1,000 ft. terrace not including breakdowns	33′ 25″	85′ 4″	43′ 42″	106′ 3″	128′ 40″	57′ 53″	124′ 23″	36′ 50″
Estimated Cost of Terrace (Sh/1,000 ft.)	21·44	25·5	25·6	68·0	38·58	33·95	37·32	21·60

KEY

V TERRACE
(1) Motor Grader 115 B.H.P.
(2) Four Wheeled Drive Tractor and Trailed Terracer (45 B.H.P.).
(3) Crawler Tractor and Trailed Terracer (64 B.H.P.).

BROAD BASED TERRACE
(4) Motor Grader 115 B.H.P.
(5) Four Wheeled Drive Tractor and Trailed Terracer (45 B.H.P.).
(6) Crawler Tractor 64 B.H.P.

CUT OFF DITCH
(7) Four Wheeled Drive Tractor.
(8) Crawler Tractor 64 B.H.P.

Sisal

A study was made of the operations involved in the cutting and transport of sisal leaf on two estates. Table II summarizes the results for three methods of cutting and bundling.

TABLE II—SUMMARY OF RESULTS FOR SISAL CUTTERS

OPERATION	25 LEAF BUNDLES				UNCOUNTED BUNDLES	
	Cutting and Counting		Counting and Bundling			
	Time, seconds	%	*Time, seconds*	%	*Time, seconds*	%
Cutting (per leaf) ..	4·26	67	4·48	57	4·64	64
Bundling (per leaf) ..	1·16	18	2·46	31	1·78	24
Carrying (per leaf) ..	0·95	15	0·95	12	0·85	12
Total (per leaf)	6·37	100	7·89	100	7·27	100
Est. time for 2,500 leaves (mins.)	265·4		326·7		302·9	

From the results of the study, two alternative systems of cutting and carrying sisal leaves were suggested for an estate cutting 10,000 bundles per day and using tractors and trailers for transport. The first method is a rationalization of existing methods, the second involves the purchase of additional equipment. These are summarized in Table III.

TABLE III

OPERATION	OLD SYSTEM	1ST PROPOSAL		2ND PROPOSAL	
	No.	No.	Saving	No.	Saving
Cutters	100	72	28	57	43
Loaders	18	14	4	14	4
No. of loads	36	36	0	21	15
Tractors	6	3½	2½	4	2

The conclusions drawn from this study were that a saving of 20 per cent in labour costs could reasonably be expected from a complete study of the industry. This saving, over an industry employing 28,000 men, would be 5,600 men who at £40 a year would represent a saving of £224,000, or about £5 per ton of fibre produced.

Pineapples

The problem of transporting pineapples from the field to factory was studied, and suggested designs for three different types of handling box put forward (*see* Table IV). The advantages of these boxes would be:—

To the Grower.—Reduced labour for loading and unloading lorries, and reduction in turn-round time of lorries.

To the Canners.—Reduction in amount of handling fruit receives before delivery, and also in the factory. Possibility for greater control over quality due to origin of fruit being known.

TABLE IV

	A	B	C	D
Length	6′ 0″	6′ 0″	4′ 0″	4′ 0″
Breadth	3′ 0″	4′ 0″	3′ 0″	3′ 0″
Height*	2′ 6″	2′ 6″	2′ 6″	2′ 6″
Tare weight lb.	394	450	210	330
Net weight lb.	1,260	1,690	840	840
Gross weight lb.	1,654	2,140	1,050	1,170

* The height is made up of 27 in. box and 3 in. for pallet.

Coffee

Two machines were tried out for stage one drying, i.e. from washing channel to skin dry.

A pneumatic separator in which coffee was fed into a pneumatic elevator, and then allowed to fall out by doubling the duct area so that the air velocity was sufficient to carry water drops but not coffee was tried, and appeared capable of removing up to 6 per cent of the water on initial trials with small batches. When set for continuous operation at maximum capacity (approximately 1,750 lb. wet beans per hour) the separation was only in the order of 2 per cent. The maximum throughput of the elevator with an air velocity of 70 f.p.s. (1,500 c.f.m.) was only 1,750 lb. per hour instead of the three to five tons that would have been expected with dry grain, such as wheat.

An experimental cascade drier was constructed to determine the flow characteristics of fluidized beds of coffee.

Trials were made altering the angle of the trays, and varying the airflow through them. Using trays 3 ft. × 1 ft. an even flow of coffee could be achieved with a slope of 8° to 11° for relatively dry coffee, while the top trays had to be between 15° to 20°, according to the condition of the coffee entering the drier.

The material used for the trays (either coffee wire or perforated aluminium) did not appear to affect the slope at which the beans begin to flow, and variations of ± 2° do not appear to alter the rate of flow.

Airflow is critical, and on the coffee wire trays a velocity of 1,200 to 1,400 f.p.m. was the optimum, whereas for the perforated aluminium it was down to 800 to 900 f.p.m., due to the relatively small percentage opening of the perforated plate.

The experimental drier with wire perforated aluminium trays had a throughput equivalent of 650 to 700 lb. coffee per hour drying from fully wet to skin dry using hot air at 150° F. The coefficient of performance was 0.65 to 0.70.

Publications

(1) Paper on Pineapple Handling (read to the Ndarugu Growers Group, 8th April, 1959).

(2) A Study of the Operations Involved in the Cutting and Transport of Sisal Leaves (distributed to members of the K.S.G.A.).

I. M. JOHNSON,
Agricultural Research Officer (*Engineering*).

ANNUAL REPORT OF THE AGRICULTURAL RESEARCH OFFICER, CENTRAL PROVINCE, 1959

Rainfall at Experimental Stations, 1959

	Embu		Mulinduko		Kanja	
		days		*days*		*days*
January	2·79	(6)	1·59	(5)	1·49	(7)
February	0·43	(5)	0·74	(2)	0·48	(7)
March	3·21	(5)	1·70	(4)	2·16	(7)
April	8·32	(17)	5·51	(13)	8·50	(21)
May	10·48	(20)	9·27	(15)	9·75	(23)
June	0·35	(4)	0·05	(1)	0·38	(7)
July	3·19	(13)	2·21	(8)	2·37	(16)
August	1·69	(10)	0·84	(3)	0·78	(15)
September	0·80	(5)	Nil		1·70	(5)
October	0·89	(3)	Nil		1·03	(8)
November	9·44	(18)	10·99	(19)	6·38	(28)
December	2·74	(6)	1·52	(4)	1·54	(4)
Total	44·33		34·50		36·56	
1958	58·69		44·70		49·54	

Rainfall during the year has been a good deal lower than average at all stations and distribution has been poor. As a result crop yields were greatly reduced as has been the carrying capacity of the grassland. Two undersown leys at Embu were lost due to failure of the rains at the vital moment.

Reports on Experiments

1. High Bracken Zone

Fertilizer and Farmyard Manure Trials on Arable Crops

A 2^5 factorial trial has been reported in the Annual Reports since 1956. In 1959 the experiment became a 2^4 factorial with the following treatments, Sulphate of ammonia at 1½ cwt./acre, Double superphosphate at 1½ cwt./acre, Farmyard manure at 15 tons per acre, Residual lime (applied in 1958) at 6.69 tons per acre, all versus nil. The previous Magnesium sulphate treatment was abandoned. All treatments were applied and Dutch Robjyn potatoes were planted in the long rains. The trial was harvested in August. Yield figures are given below.

Yields in Bags (180 lb.) Tubers per Acre

Treatment	With	Without	Response
Sulphate of ammonia ..	84·58	77·73	+6·58
Double supers.	94·89	67·42	+27·47
F.Y.M.	112·85	49·46	+63·39
Lime (residual)	85·98	76·33	+9·65

Yield of Control Plot=24·09 bags/acre.
Mean yield of Trial=81·15 bags/acre. C. of V.=17·06%.
Significant responses p at 0·05 =10·28 bags/acre.
p at 0·01 =14·08 bags/acre.
p at 0·001=19·19 bags/acre.

The response to F.Y.M. at 15 tons per acre was very large as was the response to 1½ cwt. per acre Double superphosphate, both attaining significance at 0.1 per cent. The smaller response to Lime applied in the previous year did not reach significance level, neither did the response to ammonium sulphate. These results are a close parallel to those obtained from this trial in previous seasons.

A former fertilizer trial on a Molasses grass ley was broken in 1959 and planted to Dutch Robjyn potatoes and the following treatments applied in a 2^5 design, (*a*) F.Y.M. at 15 tons/acre, (*b*) Sulphate of ammonia at 1½ cwt./acre, (*c*) Double superphosphate at 1½ cwt./acre, (*d*) Residual double supers from an application made to the Molasses grass, and (*e*) Residual Lime at 6 tons/acre which had been applied to Molasses grass at the outset of the old trial in 1956. The treatments were applied, the trial was planted in the Gathano period (July), and it was harvested in January, 1960. Plot size was 1/40th acre and the harvested plot area was 1/60.5 acres. Yield figures are given below.

YIELDS IN BAGS (180 LB.) PER ACRE

Treatment	With	Without	Response
F.Y.M.	70·71	51·55	+19·16
Sulphate of ammonia ..	60·94	61·32	−0·38
Double supers.	67·79	54·47	+13·32
Residual lime	65·58	56·67	+8·91
Residual double supers. ..	62·12	60·14	+1·98

Yield of control plot=38·65 bags/acre.
Mean yield of Trial=61·13 bags/acre. C. of V.=7·63%.
Significant responses p at 0·05 =3·56 bags/acre.
p at 0·01 =4·97 bags/acre.
p at 0·001=6·97 bags/acre.

The responses to 15 tons F.Y.M. per acre, to 1½ cwt. Double superphosphate per acre and to the effect of Limestone applied to the grass three years previously are all significant at the 0.1 per cent level. The general yield of the trial is considerably lower than the first reported long rains planting as the Gathano in 1959 was virtually a failure.

Maize and Beans Interplanting Trial

An experiment was laid down in the Gathano in five randomized blocks to find out the economic aspect of the local farming practice where beans are interplanted in maize. Plot size was 1/40th acre. Muratha maize was planted at 3 ft. × 1 ft. spacing and beans were interplanted on the relevant plots at 1 ft. × 1 ft., thus there were two rows of beans between each maize row. Double superphosphate was applied overall at 2 cwt. per acre. Treatments and yield figures are given below. Figures for cash value are calculated on the present price of maize in Embu of Sh. 23/10 per 200 lb. bag and for Rose Coco beans at Sh. 30 per bag.

Treatment	Yield	Cash Value per acre
	bags/acre	*Sh. cts.*
Beans alone	2·31	69 30
Maize alone..	7·84	181 10
Beans interplanted with Maize seed ..	6·10 bags Maize +1·25 bags Beans	178 41
Beans interplanted at Maize emergence ..	6·32 bags Maize +1·11 bags Beans	179 29

Least Significant Difference between two cash values p at 0·05 =28/43.
p at 0·01 =39/86.
p at 0·001=56/34.

Thus in this year's poor Gathano season there would appear to have been no real difference in cash return to the farmer whether or not he interplanted his maize with beans. The small extra crop of beans has made up for the lowering of the maize yield due to interplanting and whether the beans are sown with maize or at maize emergence seems to be of no importance, at least as far as revenue goes.

Fertilizer and Manurial Trial on Established Kikuyu Grass (Pennisetum clandestinum)

This trial was laid down and has been reported on since 1956. The design is two replicates of a 2^5 factorial, plot size 1/60th acre. Estimation of treatment effects is by a single Allen autoscythe cut of 20 square yards per plot. In 1959 the only treatment to be applied was the Napier grass mulch which was first tested as a replacement for the potash treatment in 1958. The reason for this treatment was explained in the 1958 report. The trial was mown at the end of the 1959 dry season, mulch applied at the beginning of the long rains in April. In July a sample cut was taken and results are given below.

Tons Fresh Greenstuff per Acre

	N	D./Supers	Mulch	Lime	F.Y.M.
With	7·90	7·77	7·79	7·11	8·15
Without	6·59	6·73	6·71	7·38	6·34
Difference	1·31	1·04	1·08	−0·27	1·81

Plots
Yield of Control=3·08 tons/acre. C. of V.=19·8%.
General Mean of Trial 7·24 tons/acre.
Significant Differences tons greenstuff per acre P at 0·05 =0·72 tons.
P at 0·01 =0·97 tons.
P at 0·001=1·27 tons.

Responses to sulphate of ammonia at 2 cwt. per acre and to F.Y.M. at 10 tons per acre both applied in 1958 are significant at 0.1 per cent. Responses to double superphosphate at 2 cwt. per acre (applied 1958) and to the 1959 reapplication of mulch are both significant at the 1 per cent level. Since its inception in 1956, cuts taken from this trial have consistently demonstrated the beneficial effect of 2 cwt. per acre sulphate of ammonia, first applied in 1956 and then again in 1958. The herbage increases obtained have been shown to be

economic if high yielding cows are used to graze the resultant grass. Although consistent increases are obtained from 2 cwt. double superphosphate per acre these increases are at a lower level than those of sulphate of ammonia and although economic the level of possible profit per acre is much lower. The effects of both F.Y.M. and mulch applications are of academic interest but it is thought that on a smallholding in this area neither could be spared for application to grassland. There has been no response to lime since July, 1957; it was applied in 1956.

2. Star Grass and Lower Kikuyu Grass Zone

The short-term rotational trial referred to in the 1958 Report was planted to Dutch Robjyn potatoes to test the effects of preceding crops and the residual effects of fertilizer and manurial treatments from preceding years. There was no reapplication of any fertilizer in 1959.

The design of this experiment is three replicates of a 3 × 3 × 3 factorial with a plot size of 1/40th acre. Treatments tested were as follows:—

N = Double superphosphate (replaced Nitrogen) at 0, 1 and 2 cwt. per acre applied in 1958.

P = Double superphosphate at 0, 1 and 2 cwt. per acre applied in 1957.

M = Farmyard manure at 0, 4 and 12 tons per acre applied in 1957.

The results of the 1959 potato crop are given below. Yield figures are low due primarily to late planting and poor rainfall distribution; there was slight *Phytophthora infestans* incidence over all plots.

Yields in Bags (180 lb.) per Acre

N_0 (resid. P from 1958)=32·02	P_0 (resid. from 1957)=35·94
N_1 (resid. P from 1958)=36·84	P_1 (resid. from 1957)=35·91
N_2 (resid. P from 1958)=40·36	P_2 (resid. from 1957)=37·36

M_0 (resid. from 1957)=36·98
M_1 (resid. from 1957)=35·53
M_2 (resid. from 1957)=36·71

Mean yield of the Experiment=36·41 bags/acre. C. of V.=28%.
Yield of Control Plot=41·69 bags/acre.
Significant Differences p at 0·05 =5·61 bags per acre.
p at 0·01 =7·51 bags per acre.
p at 0·001=9·86 bags per acre.

N_2 (2 cwt. per acre double supers applied in 1958) significantly outyielded N_0 by 8.34 bags per acre ($p = 0.01$) but it did not significantly outyield the mean of the trial. There were no significant responses to any residual effects of the 1957 treatments. The yield of the control plot is higher than the mean for the experiment.

Farmyard Manure, Phosphate and Nitrogen Rates Trial

A new trial was laid down in 1959 to test varying rates of F.Y.M., phosphate and nitrogen on a breaking crop of Dutch Robjyn potatoes. The previous ley was Rongai Rhodes (*Chloris gayana*) and was regarded as an excellent one. In previous years at Embu tentative conclusions had been drawn to the effect that the first crop after a ley broken in the dry season was able to draw sufficient nutrients from the rapid breakdown of the ley to meet its requirements; this experiment was planted to test the veracity of these conclusions.

The design was two replications of a 3 × 3 × 3 factorial, plot size 1/40th acre. Treatments were as follows:—

N = Sulphate of ammonia at 0, 1 and 2 cwt. per acre.

P = Double superphosphate at 0, 1 and 2 cwt. per acre.

M = F.Y.M. at 0, 4 and 12 tons per acre.

Results are given below in bags per acre.

YIELDS IN BAGS (180 LB.) PER ACRE

N_0=86·19	P_0=83·60	M_0=81·22
N_1=86·14	P_1=89·56	M_1=85·34
N_2=89·78	P_2=88·95	M_2=95·55

Mean yield of the Experiment=87·37 bags per acre. C. of V.=13·2%.
Yield of Control Plot=91·00 bags/acre.
Significant Differences p at 0·05 = 7·96 bags per acre.
p at 0·01 =10·82 bags per acre.
p at 0·001=14·56 bags per acre.

The yields are quite high for potatoes at Embu and the site is regarded as a fertile one as the yield of the control plot is higher than the mean for the trial. Although no treatment has significantly outyielded the mean, 12 tons F.Y.M. per acre has given a significant increase over Nil at the 1 per cent level, and 12 tons F.Y.M. per acre has outyielded four tons F.Y.M. per acre at the 5 per cent level. There is no significant response to, or interaction between, other treatments.

Farmyard Manure and Nitrogen Trial

In the same field as the trial reported above a further experiment was laid down to test four rates of application of F.Y.M. and varying rates of Sulphate of ammonia on potatoes. Top dressing of sulphate of ammonia when the potato haulms were 5 in. high was compared with placement of this fertilizer in the seedbed. The design was two replications of a 4 × 4 factorial with a plot size of 1/40th acre.

Treatments were as follows and results are given below:—

N_0 = Nil.	M_0 = Nil.
N_1 = 2 cwt./acre Sulphate of ammonia in seedbed.	M_1 = 4 tons per acre F.Y.M.
N_2 = 1 cwt./acre Sulphate of ammonia topdressed.	M_2 = 8 tons per acre F.Y.M.
N_3 = 2 cwt./acre Sulphate of ammonia topdressed.	M_3 = 12 tons per acre F.Y.M.

YIELDS IN BAGS (180 LB.) PER ACRE

N_0=72·83	M_0=81·64
N_1=88·39	M_1=75·02
N_2=77·61	M_2=76·91
N_3=86·61	M_3=91·86

Mean yield of the Experiment=81·36 bags per acre. C. of V.=13·21%.
Yield of Control Plot=55·66 bags per acre.
Significant Differences p at 0·05 =11·60 bags/acre.
p at 0·01 =16·18 bags/acre.
p at 0·001=22·68 bags/acre.

Thus Sulphate of ammonia at 2 cwt. per acre when applied to the seedbed and when topdressed have both significantly outyielded Nil at the 5 per cent level. F.Y.M. at 12 tons per acre has outyielded both the 8 ton and the 4 ton per

acre dressing, the former at 5 per cent and the latter at 1 per cent but it has not significantly outyielded Nil. There are no significant interactions between M and N.

The natural fertility of this site appears to be lower than that of the former trial and this may account for the unexpected and quite large response to the heavier nitrogen dressing.

Coffee Variety Trial—Embu Farm

The trial was reported on in 1958, and at the time of writing it is about to change into its third cycle. During 1959 it was heavily pruned to bring up the new suckers so that the following yield figures may not be of any great value. Cherry weights only are measured on this trial and a ratio of 6:1 is used to convert cherry weights to weights of clean coffee.

S.L. 14	7·08
S.L. 28	5·55
N.197	4·15
Kents	3·53
S.L. 34	3·19
Mean	4·70

Least Significant Differences p at 0·05 = 1·92 cwt. per acre.
p at 0·01 = 2·69 cwt. per acre.

S.L.14 has significantly outyielded N.197, Kents, and S.L.34 at the 1 per cent level and S.L.28 has outyielded at the 5 per cent level both Kents and S.L.34. In the crop under report S.L.34 (which topped the list in 1958) has yielded very poorly. This is considered to be the direct result of overbearing in the 1958 season. S.L.28 and S.L.14 have, however, withstood overbearing quite well.

Two further trials, namely, (*a*) the method of mulching and anti-leaf fall spray trial, and (*b*) the manurial drop-out trial will be reported on separately by the Coffee Research Station. The latter trial to test how often F.Y.M. should be applied to coffee is still in its infancy.

3. Tea Trials, Kagochi, Nyeri District

Trials in progress until 1958 were mentioned in the report for that year.

In 1959 two new trials were started. The first was to test stake versus seedling versus stump planting combined with several interplanted shade and interrow cropping treatments. This failed due to drought and will be replanted. The second was laid down at Iriani Tea Nursery to test nematocides against root eelworms which are becoming troublesome there.

The majority of the trials on mature tea at Kagochi are of very long duration and whilst they are being carefully recorded it would serve no useful purpose to quote interim results.

4. District Fertilizer Trials

These are the subject of a separate report by the Soil Chemist.

5. Grass Woodland Zone—Mulinduko Farm

There were no statistical trials on this farm during 1959. However, the following the following observations are of interest.

A good crop of Copper King onions, planted from bulbs was obtained this year, but Bombay Red onions planted from seedlings did not do well due to the dry conditions obtaining during the long rains.

Taboran short-term maize was grown for the first time at a spacing of 2 ft. × 1 ft., a good yield of ten bags/acre was harvested, there was a certain amount of loose smut on this crop which had been noticed on other parts of the farm previously.

Rongai Rhodes grass has shown itself to be very satisfactory at Mulinduko, where on one field it was successfuly established under a nurse crop of Teff grass (*Eragrostis abyssinica*). Nzoia Rhodes is being tried for the first time here and shows a good stand at the moment.

A field scale demonstration to show the beneficial effect of F.Y.M. on Taboran maize was put down in the short rains and the visual effect is most startling.

In an observational trial of four bean varieties ex-Katumani planted in the long rains the variety known as "Herbert Sprogget" yielded 5.24 bags (200 lb.) per acre. A similar trial of sorghums was written off due to a great deal of head smut and bird damage.

A small replicated Napier grass spacing trial was resuscitated to test 4 ft., 8 ft. and 12 ft. row spacings, the 12 ft. spacing showed up best giving a yield over 4 cuts of 47 tons/acre green herbage.

M. E. H. VICKERS,
Agricultural Research Officer, Central Province.

ANNUAL REPORT OF THE AGRICULTURAL RESEARCH OFFICER, RIFT VALLEY PROVINCE, 1959

Rainfall at Selected Stations (in inches)

	1954	1955	1956	1957	1958	1959
Nakuru	42·80	37·58	39·54	38·56	48·43	39·33
Njoro	46·48	38·92	45·79	31·98	51·70	54·59
Rongai	45·08	25·36	39·76	45·22	48·11	37·97
Molo	—	45·99	46·89	44·43	50·22	41·85
Kitale	47·91	40·12	45·01	40·27	56·91	35·04
Eldoret	38·13	39·79	43·95	31·95	55·26	37·39
Ol Joro Orok	36·79	35·28	40·96	39·22	49·02	30·84
S. Kinangop	—	34·43	42·10	54·25	50·80	43·24

NAKURU DISTRICT

The year has in general been a dry one with a June-July drought which affected maize yields in the marginal areas.

SOUTH KINANGOP

The weather was seasonal during the first quarter, but the period between the long and short rains was dry. The general pattern of rainfall in the area was patchy. Temperatures were higher than normal and strong winds resulted in high evaporation losses.

OL JORO OROK

In the Thomson's Falls area the year has on the whole been dry with late rains compensating for the comparative earlier failure by an increased growth of grass. In the Mount Kenya district rainfall was below average, especially in the Timau area, where failure of the long rains followed failure of the short rains in the previous year. The rainfall conditions were more favourable in the Naro Moru area above 6,500 ft.

ELDORET

Though rainfall distribution was erratic, conditions generally speaking were ideal for crop growth. The latter half of the year produced an average rainfall with the exception of November, which was dull and wet and brought a welcome flush of grass.

KITALE

A low rainfall was producing above average wheat yields, but heavy late rains in October and November hindered harvest to some extent. Despite army worm infestation early in the year and low total rainfall, it was a good year for milk production.

Experimental Work

Full details of cereal, fertilizer, variety and observation trials may be found in the Annual Report of the Senior Plant Breeder.

Results of entomological and pyrethrum trials will be found in the respective annual reports of these sections.

The experiments outlined here are those which to date have produced positive information.

Nakuru District

Cotton.—Following successful variety trials planted at Kampi ya Moto in 1958, a follow-up in the form of a rates of phosphate fertilizer trial was carried out. This crop did not respond significantly to the three rates of triple super phosphate applied. Drought conditions prevailed for three months of the trial period and six sprayings were required to control stainers and red spider mite. The average yield of seed cotton per acre was low at 322 lb.

Potato Variety Trial.—A further variety trial was carried out at Dundori comparing the yields of 12 varieties in a randomized block lay-out using Dutch Robjyn as the control variety. The average yield was 14½ tons per acre, and the varieties K.52, Maritta, Ackersegen, Alpha and Patrones significantly out-yielded Dutch Robjyn at the 1 per cent level, while there was no significant difference in the yield between Dutch Robjyn and the varieties C.53, Oasterbrink, Pimpernel, Loman and Rival.

Note.—It is obvious that in the future variety trial, tests should be made on the quality of the high-yielding varieties as Dutch Robjyn is regarded favourably by most consumers in Kenya and such varieties as K.52, which tends to discolour on cooking, are not popular.

Potato Fertilizer Trials.—N.P.K. fertilizer trials of potatoes were carried out at Dundori, Mau Narok and Elburgon. In the Elburgon trial 3 cwt. of triple supers per acre gave significantly greater (1 per cent level) yields than any combination of the other fertilizers used.

In the Dundori trial, the application of triple supers and sulphate of ammonia at 3 cwt. and 2 cwt. per acre respectively gave significantly better yields than both N alone and P alone.

In the Mau Narok trial, potash again produced no effect while nitrogen in combination with phosphate yielded significantly better than all other treatments.

Potato Seed Trial.—A trial was conducted at Mau Narok comparing cut and uncut seed. In this trial, uncut seed produced a significantly higher yield than cut seed. The mean yields in tons per acre from this trial were as follows:—

	Tons per acre
Uncut	10.25
Cut	8.4

South Kinangop

Grass Observation Trials.—A total of 23 varieties of grasses and clovers were planted at North Kinangop and from observations the most suitable of the grasses in this area would appear to be:—

Rye grasses, perennial and annual.
Cocksfoot (S.143 and Danish).
Phalaris tuberosa.
Nandi Setaria.

Agricultural Station, South Kinangop.—Of a total of 17 grasses and clovers sown in August, 1958, the following yields of green matter were recorded from 14 months' growth. The outstanding varieties of grasses were:—

	Tons per acre
Nandi Setaria	42.0
Phalaris tuberosa	35.8
H.I. Ryegrass	29.0
Endebess Rhodes	28.9
S.24 Perennial Ryegrass	25.7
S.143 Cocksfoot	26.8
New Zealand Italian Ryegrass ..	22.5
S.22 Italian Ryegrass	22.0

Of the legumes, the following were the best yielders:—

	Tons per acre
Louisana White Clover	10.2
Saladina Lucerne	6.8

Four varieties did not produce sufficient to allow a cut to be made, namely Timothy, Kentucky Bluegrass and Alsike.

Potato Trials.—Nine Mexican blight-immune varieties were tested and of these three succumbed to blight.

Eldoret

Types of Manure on Maize.—This trial was continued from 1957 and 1958 comparing cattle farmyard manure at ten tons per acre, poultry farmyard manure at ten tons per acre, double supers at 200 lb. per acre, pig manure at ten tons per acre and Control.

The trial had still to be harvested at the end of the year, but the following order of response was scored visually:—

1. Pig manure.
2. Poultry farmyard manure.
3. Cattle farmyard manure.
4. Double supers.
5. Control.

Economic Phosphate Trial.—A trial to compare the effect of application of phosphatic fertilizers when applied at the same monetary value per acre. The treatments included double superphosphates 10.20.10.4T, 10.30.0, Kenaf No. 2 and Control, the crop being maize. An index of performance based on the combined scores of various factors gave the following declining order of response:—

1. 10.20.10.4T.
2. 10.30.0.
3. Double supers.
   Kenaf No. 2.
4. Control.

Castor Observation Plots.—Single plots of inbred and hybrid varieties were planted on 30th May. Harvesting was not completed at the end of the year and both varieties suffered from a form of rust, *Melamsporella ricini.*

Potato Variety Trial.—Eleven varieties were compared and yields were generally good with C.52 at 15.6 tons per acre, P.57 at 11.5 tons per acre, N.57 at 10.24 tons per acre and L.57 at 10.14 tons per acre. These were the highest yielders.

Green Manures.—Following the results of 1958, a trial on sunflower ploughed in prior to a crop of barley was carried out on a field scale during 1959. The operation was extremely successful in that barley yielded 9.5 bags per acre.

Vlei Observation Plots.—A variety of crops were grown in single plots on the *flat* on a poorly drained vlei with a basal application of 100 lb. per acre of double super phosphates.

RESULTS

Mangolds	Royal Monarch ..	Roots 2·92 tons per acre Tops 0·89 tons per acre
	Broadacre	Roots 4·43 tons per acre Tops 0·96 tons per acre
Kale	Marrowstem ..	Leaf 0·97 tons per acre Stem 1·28 tons per acre
	Thousand Headed..	Leaf 0·97 tons per acre Stem 0·27 tons per acre
Rhodes Grass (Rongai)		6·9 tons per acre green material
Lucerne	Hunter River ..	1·3 tons per acre green material
	Hairy Peruvian ..	0·81 tons per acre green material
Nandi Setaria		4·51 tons per acre green material

Soya beans were planted, but as these are greatly relished by buck it was not possible to harvest them.

RYE OBSERVATION PLOTS.—Two half-acre plots of rye were sown with 100 lb. per acre double super phosphate. This crop was vigorous and yielded well at 13.5 bags (160 lb.) per acre.

LIVESTOCK

CALF EARLY WEANING

This trial was a repeat of the 1958 trial and results followed a similar pattern; the average daily gain per calf being 1.03 lb. per day on the early weaning treatment and 1.01 lb. per day on the standard whole milk treatment. The early weaning treatment, while not apparently producing such high rates of gain gives a more consistent and uniform rate of gain at a more economic level. Observations on these animals will be carried through so that liveweight and lactation figures will be available.

PIGS

1. *A Protein Study Involving the Feeding of Two Similar Rations with and without* 1.6 *Grams Antibiotic per Hundredweight of Meal.*—The ration was composed of—

62 per cent maize;
20 per cent barley;
16 per cent meat meal;
2 per cent minerals,

fed to 120 lb. liveweight.

The ration thereafter was composed of:—

70 per cent maize.
20 per cent barley.
8 per cent meat meal.
2 per cent minerals.

At 19 weeks of age, those pigs fed on the ration not containing antibiotic had nicotinic acid added which, although it cleared up the prevalent dermatitis,

growth rate was still depressed. On the addition of blood meal to both rations, growth and conversion rates improved. The conclusions which may be drawn from this trial are:—

(*a*) Local meat meal, in spite its its high protein content, is unsuitable as the sole protein supplement to a cereal ration, due to its deficiency in certain amino acids. It can, however, be of value when employed as a component of a protein supplement mixture.

(*b*) The addition of an antibiotic to a pig ration which is deficient in certain amino acids, has no beneficial growth effect.

2. *Comparison of Maize as Meal with Maize "on Cob".*—This trial showed a slight advantage to the maize as meal in the rate of liveweight gain, conversion ratio and cost. But grading was not quite so good as the maize "on cob" treatment. The net value of the pig produced, however, was again slightly in favour of the maize as meal ration.

SHEEP

Highland Mutton Production.—A trial was carried out comparing two grazing treatments with Corriedale lambs.

Group 1 was grazed on Rhodes grass, a pasture, and Group 2 grazed on rape.

After 28 days liveweight gains were:—

Pasture group	.. .. ..	0.5 lb. per week
Rape group	.. .. ..	1.1 lb. per week

Unfortunately one of the lambs in the rape group died as a result of a digestive disorder caused by the exclusive rape diet. The trial was therefore unfortunately suspended.

Climatological Studies.—A pilot trial was commenced in an attempt to correlate respiration rates and body temperature with air temperature. Two treatments—

(i) shaded under a roof during the day and run out at night; and
(ii) outdoors continuously.

Three Corriedales and one native ewe with lamb at foot were placed in each treatment. Body temperature and respiration rates were measured and correlated with simultaneous air temperature, solar radiation, relative humidity and rainfall measurements.

After two months no definite correlation could be observed, but something of a direct linear relationship existed between solar radiation respiration rates and body temperature.

Ol Joro Orok

GRASS OBSERVATION TRIAL

Timau.—Eight species of grass were sown in 1958 at Timau at an altitude of 7,800 ft. These included:—

1. H.I. Ryegrass.
2. Timothy.
3. Mountain Brome.
4. *Paspalum dilatatum.*
5. N.Z. Prairie Grass.
6. Rongai Rhodes.
7. K.31 Fescue.
8. *Bromus uniloides.*

All species established well except for *Paspalum dilatatum*. The superior species with respect to growth and yield of green material were:—

H.I. Ryegrass, *Bromus uniloides*, K.31 Fescue.

The order of palatability:—

H.I. Ryegrass, Timothy, K.31 Fescue, *Bromus* sp.

Mweiga.—Altitude 7,500 ft., sown 1957. The six species compared were:—

1. H.I. Ryegrass.
2. Westernwolths.
3. Italian Ryegrass.
4. S.26 Cocksfoot.
5. S.143 Cocksfoot.
6. S.37 Cocksfoot.

All Ryegrasses grew well in the first year, but thereafter fell away. All strains of Cocksfoot suffered from leaf rust. The best species for persistency and yield was H.I. Ryegrass. No yield figures are available.

Naro Moru.—Altitude 7,000 ft. The same species as at Mweiga were tried. All species grew well except for S.143 Cocksfoot. The annual Ryegrasses suffered mildly from leaf rust. No yield figures are available.

Ol Kalou.—Red soil, altitude 8,500 ft., sown 1959. The seven species compared were:—

1. Timothy.
2. Westernwolths.
3. *Bromus uniloides.*
4. Rongai Rhodes.
5. Nandi Setaria.
6. S.24 Ryegrass.
7. Purple Vetch.

Drought affected growth considerably, but establishment of Setaria and Rhodes was in any case poor. One yield cut was taken giving:—

	Tons Green Material Per Acre
Vetch	12
Westernwolths	$2\frac{1}{2}$
S.24 Ryegrass	2
Timothy	$1\frac{1}{2}$
Rongai Rhodes	$\frac{1}{2}$
Nandi Setaria	Negligible

Ol Kalou.—Altitude 7,600 ft., vlei land, sown 1958. Observation plots comparing:—

1. Nandi Setaria.
2. *Phalaris tuberosa.*
3. Westernwolths Ryegrass.
4. Timothy.
5. Ronpha.
6. Kentucky Bluegrass.
7. Louisiana White Clover.

No yields are available, but throughout the dry season the only varieties remaining green were Ronpha and Kentucky Bluegrass. Timothy and Louisiana White Clover failed to establish. In the second year the only species of grazing value were Nandi Setaria, *Phalaris tuberosa* and Ronpha.

Phosphate Application Trial to Leys

A trial was sown in 1957 at Naro Moru comparing nine phosphate treatments on the establishment of Rhodes grass and the plots were split for legumes versus no legumes. Of the three cuts which have been taken, there has been no significant difference between main or sub-treatments.

Peas

Observations on growth and yield of two varieties were carried out. These varieties, Unica and Alaska, yielded respectively 630 lb. per acre and 560 lb. per acre of seed.

Bush Control Trials

Interim results of trials with mechanical and chemical treatments are summarized as follows:—

Chemical Sprays.—Various concentrations of 2.4.5T in oil and water have been tried and in combination with 2.4D mainly on *Euclea divinorum* and *Carissa edulis.* These were done in 1957, and at the end of 1959 growth of bush was back to normal. No kill was recorded on any species and painting cut stumps had no adverse effect on regeneration.

Mechanical Treatments.—Machines used have been the Gyramor, Holt Mark IXA bush breaker, a Fleco root plough on *Euclea divinorum* and the Holt, Fleco, and chaining on *Acacia* species.

(1) *Euclea divinorum.*—The Gyromor proved capable of clearing quite large areas of *Euclea* and regrowth, even two years later, was only slight and manageable by further use of the Gyromor.

The Holt bush breaker was disappointing on *Euclea.* Two years later the bush was thicker than ever. The plant had bushed up from the base and growth was vigorous.

The Fleco root plough was used in September, 1959, and it is too early to estimate its value.

(2) *Acacia* sp.—Chaining has yielded the poorest results in terms of control of bush. More than 60 per cent of the trees were not felled, but remained at an angle of 30 degrees to the ground and have not been checked by the treatment.

The Holt bush breaker produced promising results on free-draining soil. Even here there was a 70 per cent regrowth from the base of the plants. This regrowth over a 12-month period was 12-15 in. in length, and grass growth on the area has been insufficient to give a hot burn.

The Fleco root plough gave promising results, although it is too early to estimate its true effectiveness. There has been no regrowth after four months.

Animal Husbandry

Zero Grazing Studies.—This trial is proceeding satisfactorily, but it is of course too early for any positive information to have been gained. Preliminary results emerging however are:—

(i) With court-fed cattle, there has been no incidence of bloat as compared with the strip-grazed cattle where trouble of this nature has occurred.

(ii) Court-fed cattle consumed 100 per cent of cut kale, while the grazing herd consumed only 83 per cent, the material left being the stalks of the kale.

(iii) Kale-grazed *in situ* tainted cream so that it was downgraded to Grade III. Kale cut and fed in the court the same day did not impart a cream taint.

Beef Court Finishing Trial.—This trial was intended to compare the first crosses of—

Hereford × Boran;
Aberdeen Angus × Boran;
Red Poll × Boran,

for beef production and a comparison of court finishing versus grazing for these crosses. Unfortunately, however, the age of the animals introduced to the trial was variable, and before the animals were finished it was necessary to send them off for slaughter as feed stuff was not available for the continuation of the experiment.

The following tables will, however, indicate that with the type of finishing court used, the court feeding produces no advantage over finishing on grazing, nor did the addition of concentrates to a fodder ration. Further analyses of the micro-climatic conditions existing in the feeding courts used may throw additional light on the apparently poor conversion obtained from the inside groups of steers.

Comparison of Gross Returns Per Head Inside Versus Grazing Inside Groups of Steers

Ration	Cost of Ration	Gross Profit/Head
I. 6 lb. conc. 1 lb. Cotton feed cake .. .. 50 lb. Green oats .. .. 5 lb. Oats straw .. .. /head/day	2/22 per head/day	191/44
II. 6 lb. conc. 50 lb. Green oats .. .. 5 lb. Oats straw .. .. /head/day	2/12 per head/day	204/11
(Concentrates 1 : 1 : 1 Mixture of wheat, oats, barley)		
Outside Group		
Grazing only	1/- per head per month	437/16

Grading and Gross Returns for the Various Groups

Breed Cross	Inside or Outside	Grading	Returns by Cross per head
Red Poll x Boran ..	Outside	4As 1B 1/3rd	Sh. 428/31
Angus x Boran	,,	2As 4Bs	Sh. 422/60
Hereford x Boran ..	,,	1 1st 2As 3Bs	Sh. 460/50
Red Poll x Boran ..	Inside Ration I	1A 1B 1/3rd	Sh. 362/08
Angus x Boran		3Bs	Sh. 399/95
Hereford x Boran ..	,,	3As	Sh. 491/70
Red Poll x Boran ..	Inside Ration II	1A 1B 1/3rd	Sh. 351/81
Angus x Boran	,,	1A 2Bs	Sh. 429/85
Hereford x Boran ..	,,	2As 1B	Sh. 470/25

Kitale

Alternative Crops

Soya Bean Varieties

This is the most promising alternative crop to maize so far grown at Kitale. Unfortunately, however, soya bean virus has affected yields to some extent.

The yields from the three best varieties, namely Chome, H.49 and Ex Congo, averaged 10.5 bags per acre.

White Gram

Although the results of this trial have not yet been analysed, the average yields were higher, being 10 bags per acre in 1959 as against 7.5 bags per acre in 1958.

Castor Varieties

The harvesting of this trial is not yet complete, but the indications are that the varieties ex Katumani ripen far too unevenly to make harvesting on a large scale an economic proposition.

Animal Husbandry

Calf Early Weaning Trial

The continuation of the 1958 trial was carried out comparing calves weaned off milk at about 60 lb. liveweight (using a commercial starter to 100 lb. liveweight and thereafter calves were allowed grazing plus a young stock ration) with the standard whole and skim milk method *plus* the standard method with a maize and cottonseed cake supplement used in the proportions four parts maize to one part cottonseed cake. The average liveweight gain per day was:—

Early weaning	1.05 lb.
Milk only	1.18 lb.
Milk plus concentrate	1.18 lb.

The early weaned calves took 14 days longer to reach a 180 lb. liveweight than did those on the standard treatment.

When comparing costs of feed for each group, the figures indicate that when a farmer is using whole milk to wean early, to use a calf starter is more economical than the standard whole-milk method. The early weaning method is definitely the easiest and most labour saving of all the methods used. The value of feeding maize and cottonseed to a calf on the conventional rearing method is doubtful.

Cow Feeding Trial

The object of this experiment was to evaluate ley grasses through the dairy cow and attempt to determine whether the limiting factor was a protein deficiency, a carbohydrate deficiency or the inability of the cow to consume an adequate amount of dry matter. The reason for this was the apparent inability of Rhodes grass leys in the Trans Nzoia area to produce the amount of milk which was theoretically possible according to laboratory analyses of the grass.

High-grade cows and heifers of the Jersey breed were allocated at random to three groups. It was possible to have only seven animals per group in this trial. The treatments were as follows:—

1. Grass only.
2. Grass and coarsely ground maize meal.
3. Grass and ground cottonseed cake.

Each animal was in an individual stall and the intake of all feedstuffs was thus able to be measured accurately. The grass was fed to appetite, maize meal was fed at 6 lb. per day for the first six weeks and 6 lb. per day for the last four weeks.

Only ten weeks' results can be discussed, as due to drought conditions the animals had to be let out to graze, as grass growth was such that it was not able to be cut.

SUMMARY OF RESULTS OF KITALE COW-FEEDING TRIAL

Treatments	Milk average per Cow (lb.)	Av. dry matter consumed per Cow per day (lb.)	Av. dry matter consumed per 100 lb. liveweight per day	Theoretical milk production based on digestible protein	Actual milk production	Theoretical milk production on starch equivalent basis
Grass only	6·6	16·42	2·63	1,919·7	3,220·4	4,381·0
Grass and Maize meal	9·5	23·25	3·42	3,359·2	4,437·7	7,194·0
Grass and Cotton Seed Cake ..	9·0	20·29	3·30	7,746·0	3,315·1	7,635·0

From these results it would appear that protein is not a limiting factor to milk production, but that the cows were not producing due to a carbohydrate deficiency for milk production, but not for liveweight gain, as the animals fed maize meal all gained weight at 0.65 lb. per day over the trial period.

Dry-matter production would not appear to be a limiting factor, e.g.—

Trial.—Average dry matter consumed 29.98 lb. by animals averaging 639 lb. liveweight;

Rations for Livestock.—Average dry matter consumed 15.75 lb. by animals averaging 5½ cwt. liveweight,

as being the appetite for animals of that weight.

The average daily intake of water on the other hand was low at 4.55, 4.66 and 4.53, which were the average daily intakes of water in gallons per animal per day for each of the three treatments. It would appear therefore that the quality of the grass used is not completely balanced for the optimum milk production, but the raising of the intake of digestible protein did not appear to improve this quality.

Questions still to be answered therefore are:—

(*a*) Are the animals capable genetically of producing higher yields?

(*b*) Does not environment affect the situation to a large degree?

(*c*) What effects does Rhodes grass produce in other areas?

(*d*) Is the animal able to utilize fully the feed ingested?

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ANNUAL REPORT OF THE AGRICULTURAL RESEARCH OFFICER, NORTHERN DIVISION, NYANZA PROVINCE, 1959

Weather

Rainfall at Experimental Station, 1959

The monthly totals for the stations are given in the Appendix.

There is a general opinion that the rains have been unfavourable in the Northern Division of Nyanza. Early planters were badly hit by Army worm in many places and had to replant. These people, and the large proportion of Africans who always plant late, found the low May and June rainfalls too little for good establishment.

On stations such as Kakamega and Busia maize yields of 26 bags/acre were obtained.

Reports on Experiments

Observational Trial on Chillies

Four groups of six plants each were planted at 2 in. × 2in. spacing at Busia in the long rains, 1959, and ripe fruit picked and dried until finished. All seed was germinated in boxes and, after planting out, growth was good throughout. Yields were: —

(1) Flemmer Pale Flat	.. ..	3.5 lb. (6,350 lb./acre)
(2) Kakamega Common	.. ..	2.7 lb. (4,840 lb./acre)
(3) Flemmer Round	.. ..	2.0 lb. (3,630 lb./acre)
(4) Ex Matuga	.. .. ..	1.3 lb. (2,420 lb./acre)

The "Flemmer Pale Flat" was obtained from the garden in Kakamega of a Mr. Flemmer, and appeared under those conditions to ripen whilst still a pale yellow colour. At Busia, the fruit turned a bright red and was almost indistinguishable from "Kakamega Common" which it outyielded by 31.25 per cent.

It is unwise to judge from the performance of a single plot, but even 2 tons per acre is an economic yield.

Exploratory Fertilizer Trials

Eighteen long rains trials have been brought to harvest, apart from those under cotton which are not completed.

Only three short rains trials were successfully harvested.

Results are being reported on by the Soil Chemist.

Rates Trials

Three N P M 3^3 factorials were harvested in the long rains and one in the short rains.

Apart from these a N P K 3^3 factorial with two replicates at Kakamega was successfully harvested in the long rains.

Results are being reported on by the Soil Chemist.

Fodder Crops

Three hot country fodder legumes from Tanganyika were sown in Asembo location, Central Nyanza, in 1958. All three grew well, but *Pueraria phaseoloides* (Kudzu) did not set seed. *Centrosema plumieri* set a lot of seed and *Dolichos argenteus* (Yogweyogwe) a fair amount.

Grassland

Observations on a Grass Legume Grid at Kakamega

This consisted of a ley undersown to 1957 maize in which strips of Slender Guinea grass, Nzoia Rhodes and Nandi Setaria were crossed by strips of Hunter River Lucerne, Louisiana White clover and Kenya Wild White clover. It has been reported on already in the 1957 and 1958 annual reports.

Lucerne has virtually ceased to exist, Louisiana White clover is on its way out and only Kenya Wild White clover survives in abundance. Nandi Setaria is still coarse, unpalatable, and fails to cover the ground. Rhodes grass has invaded and colonized the Slender Guinea plots and the inescapable conclusion is that Rhodes grass of some kind combined with Kenya Wild White clover is the best of these combinations in Kakamega conditions.

Testing of Eight Strains of Rhodes Grass at Kakamega

These were undersown to 1957 maize and have been reported on in the 1957 and 1958 annual reports.

Early in the year Nzoia succumbed without warning and is now represented by weeds. Alego, never very thick on the ground, has been colonized by other varieties. Chepararia—a very small plot—has lost its identity. Rongai is still coarse and never fully grazed. The best now in the third year are Endebess and Mbarara. Mpwapwa and Kabarnet are also still producing well.

The Effect of Maize Spacing and Time of Underplanting a Star Grass Ley on the Yield of Maize and on the Establishment of the Ley

This experiment was started at Kakamega on 22nd April, 1959. A spacing S_3, consisting of pairs of rows 18 in. apart and 6 ft. between pairs with plants 1 ft. apart in the row (11,616 per acre), gave a better stand of grass than the closer spacings of S_1 2 ft. × 1 ft. (21,780 per acre) and S_2 3 ft. × 1 ft. (14,520 per acre), but a much worse yield.

Mean Scores for Grass Cover in pts./acre

			L.S.D.
S_1	363·00	5%	82·18
S_2	350·40	1%	128·88
S_3	473·92	0·1%	219·57

Mean Yields of Maize in lb./acre

			L.S.D.
S_1	4,889·56	5%	467·68
S_2	4,867·48	1%	733·44
S_3	4,185·84	0·1%	1,249·51

It was shown that the earlier the grass was underplanted to the maize the better the grass cover produced by harvest time.

Mean Scores for Grass Cover in pts./acre		L.S.D.	
Grass alone (no cover crop)	793·22	5%	97·26
Grass planted immediately after maize germination	500·80	1%	131·80
Grass planted after 1st weeding	252·08	0·1%	176·47
Grass planted after 2nd weeding	36·97		

But the remarkable point about this experiment is the lack of significantly depressive effect of the grass on the maize. In fact the reverse is encountered, maize yields being higher the earlier the grass is planted.

Mean Yields of Maize in lb./acre

Grass planted immediately after maize germination..	4,797·04
Grass planted after 1st weeding	4,663·47
Grass planted after 2nd weeding	4,607·21
Maize alone (no underplanted grass)	4,522·78

A 62 per cent cover of grass was obtained by planting immediately after maize germination and apparently with no adverse effect on the cover crop.

This unexpected result is corroborated from last year's (1958) experiment, the surprising outcome of which was discounted as the effect of a poor growing season.

cf. 1958 Yields in lb./acre

Grass planted immediately after maize germination	2,512·70
Grass planted after 1st weeding	2,564·26
Grass planted after 2nd weeding	2,159·51
Maize alone (no underplanted grass)	2,390·09

Here again maize, with grass underplanted at an early stage, convincingly outyielded maize alone or maize with grass underplanted at a late stage.

Establishment of a Grass Ley Underplanted to Maize and to Soya Beans Under Various Fertilizer Treatments and Using both Rhodes Grass Seed and Star Grass Splits

The cover crops of this experiment were planted at Kakamega on 30th April, 1959, with three main fertilizer treatments; control, 100 lb./acre double supers, 5 tons/acre F.Y.M., and included "maize alone" and "soya beans alone" plots for comparison with undersown crops.

"Star grass alone" and "Rhodes grass alone" plots were planted or sown on 16th May, 1959, as a basis of comparison with the grass cover obtained from underplanting or undersowing.

Underplanting and undersowing took place on 6th and 7th July, 1959, after the second weeding.

The soya beans were harvested in two phases—on 7th September, 1959, and 14th October, 1959.

Maize alone was given a third weeding on 25th August, 1959, and all maize was harvested on 18th November, 1959.

The only fertilizer effect was that of F.Y.M. which gave a 5 per cent significant increase in maize yield, but there was no effect on soya beans and grass showed a non-significant depressive response to both phosphate and F.Y.M.

Mean Yield of Maize in lb./acre

		L.S.D.	
Control	3,747·72		
Double Supers	4,394·40	5%	701·48
F.Y.M.	4,589·93	1%	1,100·11

Mean Percentage of Grass Cover

Control	46·88%
Double Supers	35·31%
F.Y.M.	40·47%

This was not merely a question of better growth by the cover crops and consequent suppression of grass growth, as the depression was reflected also in the "grass alone" plots.

The undersowing or underplanting had no adverse effect on either the maize or soya beans, as a non-significant increase in yield was recorded in each case. (Compare previous experiment—time of underplanting a ley.)

Mean Yields of Cover Crops in lb/acre

	Maize	Soya beans
Cover crop alone	4,220·13	1,049·34
Undersown to Star grass	4,280·20	1,061·02
Underplanted to Rhodes grass	4,231·72	1,084·21

The treatments scored for grass cover are given in order of merit:—

		L.S.D.	
Rhodes grass alone	91·67%	5%	16·63
Star grass alone	81·67%		
Maize undersown to Rhodes grass	48·33%	1%	22·13
Soya beans undersown to Rhodes grass	36·25%		
Maize underplanted to Star grass	32·92%	0·1%	28·81
Maize alone	15·42%		
Soya beans underplanted to Star grass	12·50%		
Soya beans alone	8·33%		

The conclusions to be drawn are that in the fertile conditions at Kakamega, the application of F.Y.M. may have had an effect on the growth of maize but not on that of soya beans. Neither F.Y.M. nor phosphate at the rates applied has had any beneficial effect on the establishment of grass, although its subsequent growth remains to be observed. (In this connexion no subsequent effects have been observed in the same trial carried out last year and still under observation.)

As to the effect of grass on the crops, there were no significant differences, the yields of the undersown and underplanted crops being actually higher than the controls both in the case of maize and of soya beans. As the mean yield of maize was 4,244 lb./acre and that of soya beans 1,065 lb./acre this result is not merely the outcome of a generally poor harvest.

As to the effect of the crops on the grass, this was very much as expected. Even in the more open spacing of the maize Rhodes grass only achieved a 48 per cent stand, whilst Star grass was only 33 per cent. In the closer spacing of the soya beans, Star grass splits, planted as late as the second weeding, found the cover too much and succumbed, giving less ultimate grass than the maize alone treatment. Rhodes grass gave a 36 per cent cover in the aggregate; but, as plot scorings varied from 9 to 0 (1 point = 10 per cent), the balance here appears to be too delicate and the treatment in practice an unjustifiable gamble. Rhodes grass throughout had the edge on Star grass in speed of growth and gave a generally better cover at harvest time, even in the grass alone plots.

The experiment shows that an attempt to establish a ley, by underplanting or undersowing grass to soya beans after the second weeding, is unlikely to succeed and is only a qualified success in maize. The lack of adverse effect on the two crops indicates the possibility of greater success with an attempt earlier in the stage of crop growth. This is borne out by the previous experiment—time of underplanting a ley.

Establishment of a Grass Ley Undersown to Maize and to Beans under Various Fertilizer Treatments and Using both Rhodes Grass Seed and Molasses Grass Seed

This was a simple version of the foregoing experiment carried out at Busia. A phosphate plus F.Y.M. main treatment was included.

The maize was planted on 21st April, 1959, and the beans planted on 23rd May, 1959, at the time of the second weeding of maize.

All grasses, including "grass alone" plots, were sown between 6th June, 1959, and 9th June, 1959, and grew so strongly that they soon smothered out the beans.

Here again the only fertilizer effects were that of F.Y.M., which gave a 1 per cent significant increase in maize yield, and that of double supers which was significantly depressive on grass at 5 per cent.

Main Effect of F.Y.M. Maize Yield in lb./acre	L.S.D.		Main Effect of P as % Grass Cover	L.S.D.	
836·92	5%	389·29		5%	5·36
	1%	610·50	5·83%	1%	7·44
	0·1%	1,040·06			

There were no significant differences between undersowing treatments in regard to grass cover, except in the case of maize undersown to Rhodes grass, which gave significantly less grass than all the rest at 0.1 per cent.

Mean Percentage for Grass Cover		L.S.D.	
Rhodes grass alone	75·0%	5%	9·29
Beans and Rhodes grass	72·5%		
Beans and Molasses grass	71·25%	1%	12·89
Molasses grass alone	70·0%		
Maize and Molasses grass	66·25%	0·1%	17·93
Maize and Rhodes grass	47·5%		

The undersowing had no adverse effect on the maize, as a substantial but non-significant increase in yield was recorded in each case.

Mean Yields in lb/acre

Maize and Rhodes grass	4,787·06
Maize and Molasses grass	4,734·12
Maize alone	4,424·06

The indications are that F.Y.M. only has had a significant effect on the growth of maize. Phosphate appears to have depressed the growth of grass, whilst not increasing the yield of maize.

As to the effect of grass on the maize, there were no significant differences, both the underplanted maize plots actually outyielding the maize alone plot. A mean yield of 4,648 lb./acre shows that this is not the result of a poor harvest.

As to the effect of the crop on the grass, this was much as expected, except that Treatment 6 (molasses grass undersown to maize) was little worse than molasses grass alone. In contrast to this, Treatment 3 (Rhodes grass underplanted to maize) was highly significantly worse than all other treatments, except, of course, "maize alone" and "beans alone".

Beans, being smothered by the grass, had little effect on its growth, so that grass undersown to beans was equivalent to grass alone.

The indication here is that, if a bean harvest is desired, grass should be undersown at a later stage.

The Effect on Subsequent Crop Yields of Continuous Cultivation Compared with a Grass/Arable Rotation, as a Mean of Evaluating the Ley

The comparison being carried out under a range of phosphate and F.Y.M. treatments takes the form of a randomized block with two replicates and is repeated at Kakamega, Bukura, Shikusa and Busia.

As both rotations started with the same crops, the experiment is concerned at present with fertilizers only and has each treatment duplicated within each block.

Apart from cotton at Busia, maize was the crop planted on the other three sites during the first year (1958) and no short rains crops were planted.

Apart from sunflower at Bukura, groundnuts were the crop on the other three sites during the second year (1959). Again no short rains crops were planted.

At Busia in 1958 the cotton showed a non-significant but sizeable response to both phosphate and F.Y.M., whereas both treatments gave a non-significant depression on groundnuts.

At Bukura the maize in 1958 was a complete failure; but the sunflower in 1959 showed a non-significant response to F.Y.M.

At Kakamega and Shikusa in 1958 there were non-significant responses to both phosphate and manure in maize. In 1959, the two sites were combined, as being on the same soil type; but the groundnuts only gave a non-significant response to phosphate and a non-significant depression to F.Y.M.

Yields have been poor throughout.

Food Crops

Maize Variety Trial

This trial at Kakamega included local selections, hybrids and synthetics and is being reported on by the Plant Breeder, Kitale.

Maize Spacing Trial

Seven spacings, giving plant populations varying from 29,040 per acre to 9,680 per acre were tried in a randomized block with four replicates per site and the experiment repeated at Kakamega, Siriba, Busia and Kimilili, under100 lb. double supers emplaced and 100 lb. sulphate of ammonia top-dressed.

Treatments

1. 3 ft. x 6 inches with 1 plant per site=29,040 per acre.
2. 2 ft. x 1 ft. with 1 plant per site=21,780 per acre.
3. 4 ft. x 1 ft. with 2 plants per site=21,780 per acre (better for undersowing).
4. 3 ft. x 9 inches with 1 plant per site=19,360 per acre.
5. 3 ft. x 1 ft. with 1 plant per site=14,520 per acre.
6. 4 ft. x 1 ft. with 1 plant per site=10,890 per acre.
7. 3 ft. x 1½ ft. with 1 plant per site=9,680 per acre.

Early mortality percentage varied with the treatment and the pattern was repeated very closely throughout the replicates at Busia, Kakamega and Siriba.

At Kimilili there is an obvious miscount in Treatment 6, as the surviving population is listed as higher than the planting rate. Apart from this, mortality was high, as mentioned above, but the mortality percentage still followed almost exactly the same order between treatments.

Average of Busia, Kakamega, Siriba		Kimilili Alone		Kimilili, Busia, Kakamega (1958 for comparison)	
Treatment	Mortality	Treatment	Mortality	Treatment	Mortality
	%		%		%
3	31·2	3	52·1	3	31·5
1	23·4	1	50·0	1	22·4
4	15·0	2	46·0	5	17·9
2	14·8	4	41·3	4	17·6
5	14·4	5	34·6	2	15·0
6	6·0	6	?	7	13·7
7	4·9	7	17·0	6	13·1

The indication is that *early* mortality is related not so much to plant population as to spacing within the row. Hence, Treatment 3, which has two plants per hole, consistently shows the highest mortality. Treatment 1, with plants spaced at only 6 in. in the row, allows competition in the early stages of growth and shows the next highest mortality.

There is little difference between Treatments 2, 4 and 5, the two former being fairly equal as the superior plant population of one is offset by the closer spacing in the row of the other. Treatment 5, having both a wide spacing in the row and between rows, has a slightly better survival rate.

A count of all surviving plants was made at harvest time as well as lodged plants, from which was calculated the lodging percentage. This was expressed as so many points per plot, i.e. 1 per cent = 1 point per plot or 60.5 points per acre. Analyses were carried out on this basis.

Mean Scoring in pts./acre

Treatments ..	7	5	6	3	4	2	1
Busia	3,785·79	4,268·28	4,349·95	4,670·60	4,682·70	4,811·26	4,995·79
Kimilili ..	1,666·78	1,929·95	1,480·74	2,019·19	2,249·09	2,663·51	2,854·09
Kakamega ..	653·40	1,382·43	1,650·14	2,285·39	2,398·83	1,840·71	2,295·98
Siriba	1,515·53	1,426·29	1,473·18	1,303·78	1,883·06	1,929·95	1,824·08
Combined ..	1,905·37	2,251·73	2,238·50	2,569·74	2,803·42	2,811·36	2,992·48

Least Significant Differences

	5%	1%	0·1%
Busia	557·11	763·15	1,039·98
Kimilili	878·44	1,203·31	1,639·81
Kakamega ..	836·69	1,146·12	1,561·87
Siriba	760·02	1,040·59	1,418·07
Combined ..	332·40	440·81	570·59

Apart from Treatment 3, the lodging percentage is strictly proportionate to plant population. In the case of Treatment 3, the early mortality was so great that the surviving plants in each case numbered less than those of Treatment 4. The inversion of Treatments 3 and 4 was, therefore, expected.

Treatment 1 had a high early mortality, but the surviving plants still outnumbered those of any other treatment. Hence, the lodging percentage was still the highest, as expected.

As to yield, the additional fertilizer enabled the land in almost every case to support a higher population, so that the standard 3 ft. × 1 ft. spacing no longer came top.

MEAN YIELDS IN LB./ACRE

Treatments ..	4	5	2	1	7	6	3
Busia	4,912·60	3,593·70	4,420·28	5,016·66	3,311·77	3,146·91	3,607·46
Kimilili	3,826·63	3,316·61	2,989·61	2,880·56	3,870·49	3,379·08	2,939·70
Kakamega ..	5,293·75	6,261·75	5,283·13	4,945·88	5,271·06	5,308·88	5,013·94
Siriba	2,344·38	1,951·13	1,875·50	1,678·88	1,981·38	2,057·00	1,709·13
Combined ..	4,094·34	3,780·80	3,777·13	3,630·49	3,608·67	3,472·96	3,317·56

LEAST SIGNIFICANT DIFFERENCES

	5%	1%	0·1%
Busia	532·53	729·47	994·09
Kimilili	668·44	915·65	1,247·80
Kakamega ..	795·01	1,089·02	1,484·07
Siriba	532·92	730·00	994·81
Combined ..	421·03	558·35	722·74

The fact that there was no significant difference between Treatment 5 (3 ft. × 1 ft.) and Treatment 4 (3 ft. × 9 in.) and that Treatment 5 uses less seed, is easier to weed, and has less lodging, still leaves the standard 3 ft. × 1 ft. spacing as the most reliable choice.

The date of thinning of the Kimilili trial is suspect and I am convinced that the effects of early competition were already serious before thinning relieved the position. Treatment 7 did not suffer as much as the others and had sturdier plants as a result. Hence its unexpected lead in yield, with resultant increase in lodging.

The Busia trial was almost too well kept and shows that under optimum conditions of husbandry the use of fertilizers will allow the closer spacing to pay off. It is believed, however, that such conditions could not in practice obtain over a large acreage, so the inclusion of the Kimilili and Siriba results in the combined analysis serves to provide a more practical setting. Treatment 4 was either top or second in three of the trials.

Cash Crops

CASTOR OIL VARIETY TRIAL

Out of 21 varieties planted in 1958 nine have been selected for further trial on the basis of yield and persistence. Yields were not good, the highest being 710.75 lb./acre.

Outstanding was a local North Nyanza variety whose chief drawback is the difficulty in dehusking. Apart from this its very large crop of very small seed has a high oil content. Almost as heavy a yielder was "Large Red Mottled", a local Machakos variety which looks like a derivative of Conner. Another North Nyanza local variety with a large seed was third and true Conner fourth.

Groundnuts Variety Trial

At the request of the Nyanza Marketing Board three trials were laid down in Elgon Nyanza.

"Homa Bay", Asiriye Mwitunde, Uganda Bunch and S.720 varieties were tried in a randomized block design and the experiment analysed for yield, incidence of Rosette Disease and *Cercospora* leaf spot.

The Western Division experiment failed owing to weed competition and non-co-operation of the farmer, who lost interest owing to shortage of rain.

The Central Division experiment experienced equally dry weather, but was well kept.

Asiriye Mwitunde had the second least Rosette and the second least *Cercospora* leaf spot. In addition, it gave nearly six bags per acre in a very dry season, nearly doubling the yield of its nearest rival "Homa Bay".

Yields are Given Below in lb./acre

		L.S.D.	
Asiriye Mwitunde	1,165·2		
Homa Bay	646·6	5%	158·07
Uganda Bunch	531·4	1%	216·52
S. 720	294·5	0·1%	295·07

Scoring for Rosette (by Plant Count)

		L.S.D.	
Uganda Bunch	16·14%		
Asiriye Mwitunde	20·00%	5%	1·46%
S. 720	25·57%	1%	2·01%
Homa Bay	28·00%	0·1%	2·73%

Scoring for *Cercospora* Leaf Spot (by Plant Count)

		L.S.D.	
Homa Bay	65·71%		
Asiriye Mwitunde	72·14%	5%	3·10%
Uganda Bunch	80·00%	1%	4·25%
S. 720	81·43%	0·1%	5·62%

On this showing Asiriye Mwitunde is the safest variety to grow in these conditions.

Observations on the Western Division trial indicated a very similar pattern. The Eastern Division trial was on higher, colder land with much more rain and the growth was checked generally. Yields were so poor as scarcely to merit report, except for the fact that yield order was almost the same.

Yields in lb./acre

		L.S.D.	
Asiriye Mwitunde	329·50		
Homa Bay	174·89	5%	54·79
S. 720	137·69	1%	74·57
Uganda Bunch	118·09	0·1%	100·59

Homa Bay significantly outyielded Uganda Bunch in both trials. (One on pallid sand and the other on basement complex.)

In this connexion it should be reported that in the long term evaluation of a ley trial, described on page 151, advantage was taken of the paired replicates at Kakamega and Shikusa (both basaltic loam) to plant one block to Homa Bay groundnuts and one to Uganda Bunch at each site. In both cases Uganda Bunch outyielded Homa Bay, and the difference in the combined analysis almost achieved significance at 5 per cent.

Mean Yields in lb./acre

		L.S.D.	
Uganda Bunch	435·47	5%	53·15
Homa Bay	383·80		

Planting Dates under Hanging Swamp Conditions

At Busia three blocks were taken as nearly identical in availability of water as possible.

On 5th March, 1959, one plot from each block was sown.

A similar group of three plots was sown on 14th April, 1959, and again on 28th May, 1959.

The early planting grew well and steadily and yielded 5,690 lb./acre (two harvests—21st July and 14th August).

The next planting grew well vegetatively, but the ears did not fill out so well. It yielded 3,195 lb./acre.

The third planting was stunted from germination and never grew more than 2 ft. high. It produced no crop at all.

Least Significant Differences

5%	845·9
1%	1,281·5
0·1%	2,060·0

March was, therfeore, undoubtedly the best planting month in 1959 at Busia.

Soya Beans Variety Trial

Three varieties, ex Belgian Congo, ex Bukura and ex Bukoba, were planted on 12th May, 1959, in a randomized block design at Kakamega.

Mean Yields in lb./acre

		L.S.D.	
Ex B. Congo	1,754	5%	214
Ex Bukura	1,711	1%	311
Ex Bukoba	1,311	0·1%	467

Ex Belgian Congo's positive habit of growth made weeding easy and picking very easy, whilst ex Bukura's more spreading habit made both the second weeding and picking a laborious process.

Ex Bukura's second and final picking was a month later than the other two (13th October, 1959).

Hence, ex Belgian Congo is undoubtedly the best choice of these three varieties for Kakamega conditions. In one plot it yielded the equivalent of ten bags per acre.

Sugar Cane Variety Trial, 25 Varieties, Second Ratoon

This trial was harvested and completed in June, 1959, at Miwani. The rainfall was generally unfavourable and yields were reduced.

The first 12 varieties appear below, firstly in order of yield of cane and secondly in yield of sucrose.

Yield of Cane			Yield of Sucrose		
Order	Variety	Tons/acre	Order	Variety	Tons/acre
1	NCo 334	39·35	1	NCo 334	3·50
2	NCo 349	34·91	2	NCo 339	3·39
3	NCo 339	32·27	3	NCo 349	3·37
4	Co 331	31·78	4	Co 301	2·97
5	Co 301	30·57	5	NCo 330	2·58
6	Co 434	28·25	6	NCo 310	2·49
7	NCo 310	26·44	7	Co 434	2·46
8	B 41227	26·32	8	Co 331	2·44
9	Co 411	25·68	9	B 41227	2·38
10	NCo 330	24·81	10	Co 411	2·31
11	Co 421	24·11	11	B 4362	2·24
12	NCo 291	23·72	12	Co 421	
13	Co 312	22·82		Co 312	2·15
L.S.D. at p—0·05		9·03			0·87
0·01		12·24			1·18
0·001		16·39			1·58

Now that the trial is completed, it is of interest to list those canes which have given the highest yield in both cane and sucrose over the whole three harvests. Those varieties are marked with an asterisk which have never fallen below twelfth place in any harvest either in cane yield or sucrose.

Yield of Cane in tons/acre			Yield of Sucrose in tons/acre		
Order	Variety	Tons/acre	Order	Variety	Tons/acre
1	Co 331*	153·94	1	NCo 339	14·62
2	NCo 339*	144·82	2	NCo 349	13·71
3	NCo 349*	144·71	3	NCo 334	12·91
4	NCo 334*	140·39	4	Co 331	12·47
5	Co 301*	136·24	5	Co 301	12·44
6	Co 434*	131·82	6	Co 434	12·29
7	Co 411	123·53	7	Co 281	11·79
8	NCo 310	121·43	8	NCo 330	11·77
9	Co 312	121·08	9	NCo 310	11·48
10	B 41227	119·30	10	B 41227	11·11
11	NCo 330*	117·17	11	Co 312	11·00
12	NCo 291	115·08	12	NCo 291	10·75
13	Co 281	113·92	13	Co 421	10·51
14	Co 419	107·47	14	Co 411	10·43
15	Co 421	107·28	15	B 4362	9·28
16	B 4362	93·74	16	Co 419	9·23

Ratoon Cane Fertilizing with Nitrogen on Sandy Soil

The second ratoon of this experiment was harvested in September at Miwani.

There were four levels of nitrogen-control, 3 cwt., 6 cwt. and 9 cwt./acre.

There were two methods of application, firstly to the trash and secondly to the soil under the trash.

There were two times of application, firstly immediately after cutting and secondly during the first short rains after cutting.

The experiment was analysed for cane yields and for sucrose yields.

The growing season was noticeably drier and rainfall undoubtedly too badly distributed for full usage of nitrogen. As with the first ratoon the 3 cwt. dressing gave an increase in yield, but this time failed to achieve significance.

A falling off in yield (although not to below control) followed the higher dressings, and left the impression of toxicity in the prevailing dry conditions.

Mean Yield of Cane in tons/acre

Sulphate of ammonia			
0	3 cwt.	6 cwt.	9 cwt.
25·74	30·55	27·42	27·73

L.S.D. p=·05 5·29

Mean Yield of Sucrose in tons/acre

Sulphate of Ammonia			
0	3 cwt.	6 cwt.	9 cwt.
2·5137	2·8392	2·5102	2·4951

L.S.D. p=·05 0·5327

The rainfall in the short rains period was less even than just after cutting, so it was not expected that time and method of application would be of interest.

The same pattern was found on analysing for sucrose yields, but this time the yields of the 6 cwt. and 9 cwt. plots actually fell to below control, indicating an effect on the sucrose percentage of the cane.

The cane from each treatment had been analysed in the laboratory and a marked variation in sucrose percentage observed. These figures were allocated to treatments on a plot basis of 1 per cent = 10 points and the statistical analysis carried out.

Mean Scores for Sucrose %

Sulphate of Ammonia			
0	3 cwt.	6 cwt.	9 cwt.
9·751	9·221	9·094	8·948

L.S.D. = ·05 0·559
·01 0·780
·001 1·093

Even the 3 cwt. dressing caused a depression almost significant at 5 per cent, whilst the 6 cwt. and 9 cwt. dressings were significantly depressive at 5 per cent and 1 per cent, respectively.

The toxicity of sulphate of ammonia applied in a dry season is thus amply demonstrated and takes effect as a depression of the sucrose percentage.

G. C. H. HILL,
Agricultural Research Officer.

Appendix

RAINFALL AT SELECTED STATIONS (INCHES) 1959

	Bukura	Siriba	Busia	Kakamega	Kibos	Kisumu	Miwani	Kimilili
January	1·16	5·49	4·7	2·45	2·16	7·62	2·64	1·56
February	5·51	2·01	1·7	3·18	3·54	2·87	3·31	4·91
March	4·16	7·70	6·0	8·67	10·64	7·48	7·10	4·92
April	7·45	8·80	13·6	9·22	6·51	5·89	6·48	5·69
May	6·97	7·57	3·6	3·67	3·29	4·84	5·75	7·91
June	2·52	3·65	3·5	3·38	0·19	1·15	1·80	3·92
July	4·83	1·75	4·7	6·93	1·05	0·66	1·60	4·87
August	5·97	5·36	6·5	4·03	3·12	1·74	3·63	4·44
September	8·59	4·12	5·4	5·25	3·90	2·70	3·85	3·82
October	8·79	8·39	4·8	7·89	3·51	0·54	6·46	2·85
November	4·33	4·43	5·0	4·24	5·41	2·39	10·20	2·66
December	3·70	3·33	1·1	3·84	2·04	2·41	3·31	0·41
Total	63·98	62·60	60·6	62·75	45·36	40·29	56·13	47·96

ANNUAL REPORT OF THE AGRICULTURAL RESEARCH OFFICER, SOUTHERN DIVISION, NYANZA PROVINCE, 1959

Weather

TABLE I—RAINFALL, 1959, FOR SELECTED CENTRES

	Sotik	Homa Bay	Kisii	Kabosson	Bomet	Senetwet
January ..	2·34	0·47	2·45	1·13	1·83	4·74
February ..	4·72	1·84	4·18	2·40	1·14	4·66
March ..	5·92	8·30	18·10	6·77	12·19	7·54
April ..	8·29	1·71	10·87	1·72	6·12	7·15
May ..	5·27	3·46	6·02	3·12	7·14	6·63
June ..	0·40	2·59	4·40	1·37	1·37	3·32
July ..	2·20	2·49	1·02	0·92	0·79	3·44
August ..	4·12	2·59	6·07	4·20	3·40	2·65
September..	3·19	6·10	8·93	1·44	1·70	1·65
October ..	2·41	7·33	5·91	2·06	2·04	2·36
November..	5·30	4·10	5·27	6·23	3·13	6·93
December..	2·80	3·59	2·77	1·96	5·31	0·60
Total ..	46·96	44·57	75·99	33·32	46·16	51·67
Average ..	51·88	44·67	79·58	—	48·12	—

The year was marked in most cases by extremely poor rainfall distribution. No real "dry season" was experienced in the early months of the year. The rains began early and came to an end abruptly in May. The next three months were extremely dry which affected crop yields considerably. Such rains as did fall generally came in large amounts, the weather turning dry again almost immediately. In most cases rainfall was experienced in October/November which coincided with harvesting.

Experimental

GRASS TRIALS

ESTIMATION OF *Setaria sphacelata* (NANDI STRAIN) AND *Chloris gayana* (NZOIA, RONGAI AND ENDEBESS STRAINS) THROUGH MILK PRODUCTION

This trial was begun at Sotik in 1959. The method briefly was as follows: the grasses were arranged in a 4 x 4 Latin Square and four carefully selected animals were superimposed on the square being completely confounded with "columns". The "rows" of the Latin Square were confounded completely with grazing times. It was thus possible on the analysis to dispose of differences between the experimental animals.

Owing to poor growing conditions early in the year only two grazings were possible in 1959. Apart from recording milk yields, sample cuts before and after grazing were taken.

Two sets of results are given. Table II shows the total milk yield in gallons per acre for two grazings and Table III shows the total yields for the third day of grazing only which was taken as giving an estimate of the feeding value of each grass when the animals were producing on the grass being eaten, and when they were not limited by decreasing bulk towards the end of grazing.

TABLE II—YIELD GALLONS/ACRE

Grass	Yield
Setaria	374·22
Nzoia	318·64
Rongai	277·06
Endebess	275·65
Mean	311·39
S.E.	±17·95
L.S.D. 5%	31·06
1%	47·06
0·1% ..	75·65

Coefficient of variation—5.8%

TABLE III—YIELD LBS. MILK/PLOT THIRD DAYS ONLY (I.E. TOTAL EIGHT DAYS)

Grass	Yield
Setaria	159·75
Nzoia	154·25
Rongai	158·25
Endebess	152·50
Mean	156·19
S.E.	±4·23
L.S.D. 5%	7·31
1%	11·08
0·1% ..	17·81

Coefficient of variation—2.7%

From Table II it can be seen that Setaria has outyielded Nzoia Rhodes (significant at the 1 per cent level) and both Rongai and Endebess Rhodes (significant at the 0.1 per cent level). Nzoia Rhodes has outyielded both Rongai and Endebess Rhodes, significant at the 5 per cent level.

From Table III no significant difference can be found between grasses although Setaria is almost significantly better than Endebess Rhodes. It would appear, therefore, that at the present level of production of the cattle used the bulk of grass produced per unit area in a given time is of far more importance than *minor* variations in palatability and food value.

This experiment is continuing and it is hoped to write a full report on this trial at a later date.

THE EFFECT OF PHOSPHATE ON THE ESTABLISHMENT OF A LEY

A trial was laid down in 1959 using *Setaria sphacelata* (Nandi strain), *Chloris gayana* (Nzoia strain) and *Cynodon dactylon* (Star grass) each with Kenya White (*Trifolium semipilosum*) and Louisiana White Clover (*T. repens*). The plots were split for phosphate versus nil in the seed bed at a rate of 150 lb. superphosphate (42 per cent P_2O_5) per acre. This was recorded in the last year's annual report.

During the long rains of 1959 the plots which had received superphosphate at seeding were top dressed at the same rate and the plots were split for a gypsum application of 2 cwt./acre.

Although the phosphate still had an effect, no significant increase was obtained from the gypsum application. A further interesting point is that only the *Trifolium semipilosum* remained in any quantity and also that Nzoia Rhodes fell behind the Star Grass in production. (*Vide* Table IV.)

Table IV—Grass Tons Fresh Matter per Acre (Four Cuts)

Grass	Yield
Setaria	18·15
Star	10·47
Nzoia Rhodes ..	9·38
Mean	12·67
S.E.	±1·28
L.S.D. 5%.. ..	3·29
1%.. ..	4·69
0·1% ..	6·78

Table V—Two-way Table to Show Phosphate and Gypsum Effects
Tons Fresh Matter per Acre

	O	P	Mean
			±0·39(2)
O	8·96	15·26	12·11
S	9·70	16·75	13·23
Mean..	9·33	16·01	12·67
	5%	1%	0·1%
L.S.D. (1)	2·83	3·96	5·60
(2)	1·14	1·54	2·07

Coefficient of Variation—10·1%

Grass Variety/Manurial Trial, Kisii

An experiment was put down at Kisii to test two varieties of *Chloris gayana* (Mbarara and Endebess) and the local indigenous star grass (*Cynodon dactylon*). The plots were split for manurial treatments consisting of a control, FYM at 15 tons per acre and phosphate at 1½ cwt. superphosphate (42 per cent P_2O_5) per acre.

Three cuts have been taken since establishment and the results are given in Table VI.

Table VI—Tons Fresh Matter per Acre

	Control	F.Y.M.	Phosphate	Mean
		SE±0·97 (1)		SE±0·76 (2)
Star grass ..	7·97	11·03	7·26	8·75
Mbarara Rhodes	8·45	15·33	14·90	12·89
Endebess Rhodes	10·55	14·37	14·32	13·08
		SE±0·56 (3)		
Mean	8·99	13·58	12·16	11·58

L.S.D.	5%	1%	0·1%
SE (1)	3·16	4·60	6·92
(2)	2·48	3·61	5·42
(3)	1·83	2·66	3·99

S.E.±2·17 tons per acre.

Coefficient of Variation—18·7%

It can be seen that Endebess and Mbarara Rhodes have both outyielded star grass at the 1 per cent level of significance. The farmyard manure was significantly better than the control (0.1 per cent level) as was phosphate (1 per cent level).

Grass Establishment Trial, Homa Bay

From past observations at Homa Bay (Lake Shore area) it was apparent that for successful grass establishment some form of consolidation was necessary. Accordingly a trial was laid down using two grasses (Star and Rongai Rhodes) and also incorporated was the use of FYM (10 tons per acre) versus nil at establishment and consolidation versus nil. The consolidation was obtained by treading with stock after the seed had been broadcast.

The Rongai Rhodes grass did extremely well in the year of establishment and was far superior to the Star grass. The manure had very little effect. The consolidation effect was only obvious in the first cut when the Grass variety × consolidation interaction almost approached statistical significance. (*Vide* Table VII.) The results in terms of tons fresh matter per acre are given in Table VIII.

Table VII—Mean of M and No M Tons/Acre—(First Cut Only)

	Star grass	Rongai Rhodes	Mean
	SE±0·34		SE±0·17
Control	0·74	3·59	2·17
Consolidation	0·45	4·35	2·40
	SE±0·17		
Mean	0·60	3·97	2·29

Interaction L.S.D. 5% 1·60 tons per acre.

Table VIII—Yield Tons Fresh Matter per Acre

Star Grass	Rhodes grass	Star/Consolidation	Rhodes/Consolidation	
2·46	7·92	0·81	7·98	
Star/FYM	Rhodes/FYM	Star/FYM/ Consolidation	Rhodes/FYM/ Consolidation	Mean
1·00	8·52	0·02	9·12	4·85

Coefficient of Variation—25·1%
S.E.±1·22 tons per acre.

Fodder Grass Trial, Sotik

Six different fodder grasses were put down to trial in 1959. These were planted towards the end of the long rains and as a result suffered from drought while establishing. The resulting yields show a high coefficient of variation (28.2 per cent), but as the plots have been gapped this should improve next year. Yields for 1959 are shown in Table IX in tons fresh matter per acre.

TABLE IX

Grass	Yield
Pennisetum purpureum	15·97
Setaria splendida	13·74
Panicum maximum	8·82
Phalaris spp. (*Ronpha*)	8·60
Panicum makarikariensis	4·31
Tripsacum laxum	3·76
Mean	9·20
S.E.	±2·60
L.S.D. 5%	4·73
1%	6·72
0·1%	9·73

The *Tripsacum laxum* (Guatemala grass) appears to be growing more strongly now it is established, but it is felt that under these conditions it will not do well.

THE IMPROVEMENT OF NATURAL GRASSLAND BY DRILLING CLOVERS INTO THE SWARD, SOTIK

In 1959 Kenya White Clover (*Trifolium semipilosum*) and Ruepells' Clover (*T. ruepellianum*) were sown into prepared lines in a Kikuyu Grass/Couch/Star pasture.

The first sowing was killed by drought but the second planting has grown strongly and a large amount of clover can be seen on the plots. Each plot was split for phosphate at 150 lb. superphosphate (42 per cent P_2O_5) per acre versus nil and also included was a plot which had not been sown to clover. This was to enable the effect of the clover itself to be measured without complicating this by the inclusion of cultivation effects.

So far it has not been possible to cut the plots, but from observations it appears that there is an effect from the phosphate, but in spite of strong clover growth there is little or no direct effect of this in evidence in the growth of grass.

Crop and Fertilizer Experiments

POTATO VARIETY—MANURIAL TRIAL, SOTIK

A variety, fertilizer and manure trial was laid down at Sotik in the long rains of 1959. The varieties of potatoes used were E52 and Dutch Robjyn. Three rates of a 10.20.10 fertilizer mixture were used, namely control, 5 and 10 cwt. per acre, and manure was applied at 0 and 15 tons per acre. The design used was a 3 x 2 x 2 factorial design with three replications.

The trial was planted towards the end of the long rains and the growth was undoubtedly curtailed by the unseasonal drought of June/July/August. Rain came too late to have any marked effect on later growth and bulking.

TABLE X—TONS CLEAN POTATOES PER ACRE

	Fertilizer (cwt./acre)				Variety	
	0	5	10	Mean	Robjyn	E52
Manure, tons/acre—						
0	2·52	6·54	6·88	5·31	5·21	5·41
15	4·91	6·69	7·12	6·24	6·56	5·92
Mean..	3·72	6·62	7·00	5·78	5·89	5·67
Varieties—						
Robjyn	3·87	6·90	6·89	5·89		
E52	3·57	6·33	7·11	5·67		

S.E. 0·44 tons per acre.
Coefficient of Variation—7·6%.

The increase (77.7 per cent) due to 5 cwt. of fertilizer per acre was significant at the 0.1 per cent level as was that due to 15 tons of manure per acre (17.5 per cent). There was no significant difference between Dutch Robjyn and E52 although the former slightly outyielded the E52 (3.7 per cent). (*Vide* Table X.)

The plots were drilled to kale in the short rains and this was cut in early January. The residual effects were extremely large mainly as a result of the poor growth on the control plots where virtually nothing grew at all. The results are given in Table XI in tons fresh matter per acre.

TABLE XI—TONS KALE (FRESH MATTER) PER ACRE

	Fertilizer cwt./acre			
	0	5	10	Mean
0	0·22	8·75	10·09	6·35
Manure tons/acre				
15	6·19	11·38	10·58	9·38
Mean ..	3·21	10·07	10·33	7·87

S.E. 1·59 tons per acre.
Coefficient of Variation—20·2%.

The increase due to 5 cwt. of fertilizer (213.7 per cent) was significant at the 0.1 per cent level and that due to 15 tons per acre of manure (47.7 per cent) was also significant at the same level.

Maize Fertilizer Trial, Sotik

An experiment involving three populations (7260, 14520 and 29040 per acre) and the three rates of phosphate and nitrogen, i.e. 0, 2 and 4 cwt. per acre superphosphate (42 per cent P_2O_5) and 0, 2 and 4 cwt. per acre sulphate of ammonia respectively was repeated in 1959. At the same time a residual trial was run on the site of the previous year's experiment.

Results are given in Table XII for the 1958 trial and its residual in 1959 and also for the repeat in 1959.

TABLE XII—YIELD BAGS (200 LB.) PER ACRE

Treatment	Yield 1958	Yield 1959 Residual	Yield 1959 Repeat
Population—			
7,260 plants/acre	21·66	15·01	13·29
14,520 plants/acre	26·04	18·62	12·23
29,040 plants/acre	22·14	17·72	13·35
Superphosphate—			
0 cwt./acre	18·21	14·07	8·96
2 cwt./acre	24·50	18·21	13·29
4 cwt./acre	27·12	19·07	15·18
Sulphate of Ammonia—			
0 cwt./acre	23·36	17·27	12·61
2 cwt./acre	21·97	17·34	13·29
4 cwt./acre	24·51	16·75	11·96
Coefficient of Variation	17·2%	27·2%	17·1%
S.E. Bags per acre	4·00	4·65	2·16

Both the residual trial and the repeat trial this year showed marked decrease in yield due to abnormal growing conditions in June and July. This was shown by the lack of response to plant population. However, both the residual effect due to phosphate and the effect of phosphate in the new trial were marked, the percentage increase in the former being 29.2 per cent and the latter 53.2 per cent where 2 cwt. of superphosphate per acre was applied.

WHEAT VARIETY TRIAL, SOTIK

A wheat variety trial was conducted at Sotik with varieties sent from the Plant Breeding Station, Njoro. Storms laid some varieties near harvest time and there was a certain amount of bird damage to plots. Results are given in Table XIII in bags (200 lb.) per acre.

TABLE XIII

Variety	Yield
Africa Mayo	7·97
Number 43	6·37
Rushmore Selection	6·23
Kenya Frontana Mayo	5·60
Impala	4·68
358 AA	4·68
Wisconsin 245 x Supremo	4·37
II 462	4·30
Maida M. Exchange	4·08
Veranopolis	3·89
Vadeiro	3·11
Regent	2·71
Sabanero	2·41
Mean	4·65
S.E.	±0·63
L.S.D. 5%	1·95
1%	2·74
0·1%	3·87

Acknowledgements

Thanks are due to the officers in charge of the stations at Kisii, Homa Bay, Bomet, Kabosson and Senetwet.

The assistance of the Grassland Research Station, the Scott Agricultural Laboratories and the Entomologist (Kibos) is acknowledged gratefully. Further, the co-operation of the District Agricultural Officer at Kisii and Kericho, and especially of Mr. Stern and also the Farm Manager at Sotik (Mr. D. Nicholson), is appreciated gratefully.

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ANNUAL REPORT OF THE AGRICULTURAL RESEARCH OFFICER, SOUTHERN PROVINCE, 1959

Weather

	Katumani 5,300′		Kampi ya Mawe 3,700′	
	Rainfall	Days of Rain	Rainfall	Days of Rain
January	1·42	9	1·94	8
February.. ..	0·71	3	0·50	3
March	5·51	10	4·98	7
April	3·18	12	1·50	6
May	4·40	6	1·20	4
June	—	—	—	—
July	0·01	1	—	—
August	0·16	3	0·45	4
September ..	0·06	1	—	—
October	—	—	—	—
November ..	6·23	18	5·65	16
December ..	1·81	8	1·80	5
Total ..	23·49	71	18·02	53

Although the totals for the year are not much below average the distribution has led to moderately severe drought conditions over the Province. The smaller rainfall in the months of April and May at the much hotter station of Kampi ya Mawe as compared with Katumani proved the value of the new maize variety, Taboran, released by the department; Taboran produced a small crop while the local maize failed completely.

Fertilizer Trials

A trial to study the effect of applying sulphate of ammonia to maize has been running for four seasons at Katumani on a latosolic soil derived from gneiss and known as Makaveti red loam.

With rains tailing off just as the crop's water requirements reach a maximum the timing of the application of sulphate of ammonia for maximum benefit is most important. The trial used on this experiment was a single replicate of a $3 \times 3 \times 3$ factorial in three blocks with sulphate of ammonia at three levels, none (N_0), 1 cwt./acre (N_1), 2 cwt/acre (N_2); three plant operations, 5,000 plants per acre (P_0), 7,500 plants per acre (P_1), 10,000 plants per acre (P_2); and three times of application, placed in the seedbed at planting (T_0), top dressed when the plants were at 3-4 leaf stage (T_1), and top dressed when the plants were knee high (T_2).

In 1958 the results with a long-term yellow maize used by local farmers were as follows:—

Table 1—Yield of Yellow Maize in Lb./Acre. Long Rains, 1958

N_0	2,178	T_0	2,421	P_0	1,981
N_1	2,286	T_1	2,250	P_1	2,232
N_2	2,295	T_2	2,088	P_2	2,546

Significant differences—
P at 5% ±216 lb./acre
1% ±298 lb./acre

Coefficient of Variation = 9·5%.

The rainfall during the growing season of this crop was 13.30 in. falling in the first two and a half months with none in the next three. It is interesting to note that although the increases from the one and two hundredweights of sulphate of ammonia are slight there is a marked difference due to time of application; seedbed application outyielding the knee height dressing by 333 lb. per acre. Unfortunately stover yields were not recorded and it is impossible to say whether this is a straightforward response to the early application of nitrogen or a depression due to the late dressing delaying maturity and leaving the maize more susceptible to the drought of the last three months.

In the long rains, 1959, the trial was repeated with the same treatments but the maize used was the much shorter term variety, Taboran. Rainfall was adequate for the first two months, 8.39 in. but no rain fell in the next two months the crop was on the ground.

Table 2—Yield of Taboran Maize in Lb./Acre. Long Rains, 1959

N_0	1,398	T_0	1,470	P_0	1,111
N_1	1,434	T_1	1,407	P_1	1,438
N_2	1,470	T_2	1,425	P_2	1,703

Significant differences—
P at 5% ± 76 lb./acre
1% ±106 lb./acre
0·1% ±146 lb./acre

Coefficient of Variation=5·3%.

In this year besides the lack of response to sulphate of ammonia there was no response to time of application. In contrast to these two seasons the short rains of 1958 with 9.02 in. well distributed provided good growing conditions throughout the season. The variety of maize was Taboran.

Table 3—Yield of Taboran Maize in Lb./Acre. Short Rains, 1958

N_0	2,501	T_0	2,976	P_0	2,241
N_1	2,940	T_1	2,970	P_1	2,895
N_2	2,949	T_2	2,644	P_2	3,254

Significant differences—
P at 5% ±406 lb./acre
1% ±614 lb./acre

In this season the response to sulphate of ammonia at 1 cwt./acre is significant at the P = 5 per cent level with an increase of 439 lb./acre and time of application has had no effect.

In all three seasons there have been marked increases in yield with the higher plant population and it seems likely that bigger stands still will result in higher yields particularly with the variety Taboran.

Another trial at Katumani which has been running for four seasons compares the effects of double superphosphate and farmyard manure on maize. Again the trial was in the form of a 3 × 3 × 3 factorial in a single replicate comparing double superphosphate and 1 and 2 cwt./acre against none and manure at 7½ and 15 tons/acre against none. The third treatment has been left for a reapplication of either of the other two treatments but so far has not been applied. Reliable results have only been obtained in two of the four seasons but these bear out the responses that would be expected from results elsewhere on soils of a similar nature, i.e. latosolic red loams derived from gneiss.

The trial was started in the short rains of 1957 on newly broken land but responses although present were small and did not reach significance. The results of a yellow maize crop in the following rains of 1958 showed marked responses to the residue of the 1 and 2 cwt./acre of double superphosphate; the yield increase from 1 cwt. was 286 lb. per acre and from 2 cwt. 448 lb. per acre. Similarly the response to residual farmyard manure was 197 lb./acre at 7½ tons/acre and 430 lb./acre at 15 tons/acre. The increase to 15 tons/acre over 7½ tons/acre was also significant at 233 lb./acre.

TABLE 4—YIELD OF YELLOW MAIZE IN LB./ACRE. LONG RAINS, 1958

Double superphosphate		Farm Yard Manure	
0	2,026	1	2,061
1 cwt/acre	2,312	7½ tons/acre	2,259
2 cwt./acre	2,474	15 tons/acre	2,492

Significant differences—
P at 5% ±170 lb./acre
1% ±235 lb./acre
0·1 ±324 lb./acre
Coefficient of Variation 7·4%.

By the long rains of 1959 using Taboran maize the effect of farmyard manure applied in 1957 had almost gone but the response to double superphosphate was still present although there is little difference between the two rates of application.

TABLE 5—YIELD OF TABORAN MAIZE IN LB./ACRE. LONG RAINS, 1959

Double superphosphate		Farm Yard Manure	
0	1,245	0	1,371
1 cwt./acre	1,506	1½ tons/acre	1,452
2 cwt./acre	1,578	15 tons/acre	1,506

Significant differences—
P at 5% ±152 lb./acre
1% ±210 lb./acre

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ANNUAL REPORT OF THE AGRICULTURAL RESEARCH OFFICER, COAST PROVINCE, 1959

Weather

The long rains at the Coast were generally satisfactory this year and good yields were obtained despite a long dry spell which lasted from mid-May until late June. The short rains were very poor and failed completely in some areas.

RAINFALL AT EXPERIMENTAL STATIONS (INCHES)

	Matuga	Mtwapa	Msabaha
January	0·95	0·64	1·85
February ..	1·35	1·10	0·47
March	0·32	0·00	1·74
April	12·57	24·50	18·56
May	6·65	6·45	4·05
June	3·07	4·93	8·86
July	3·34	7·00	4·34
August	3·25	3·48	3·95
September ..	0·38	0·45	0·15
October	1·22	1·28	1·73
November ..	3·14	0·13	0·49
December ..	3·17	2·41	0·98
Total ..	39·41	52·37	47·17

Cassava

VARIETY TRIAL I

In 1957 a variety trial comparing eight of the Amani Hybrid cassavas was planted at Matuga. The design of the experiment was randomized blocks with plots 1/40th acre in size. Cultivation was on 4 ft. ridges at a spacing of 4 ft. × 4 ft. The trial was harvested in 1959 after being in the ground for 23 months. The yields are given in Table I.

TABLE I—YIELDS OF CASSAVA ROOT IN TONS/ACRE

Variety	Yield	Variety	Yield
4697/4	6·1	5315/39	9·1
46106/26	13·8	5317/21	5·6
46106/27	11·1	5318/34	4·9
5312/22	7·4	5342/1	7·1

S.E. = ±0·90 tons/acre.

L.S.D. at P = ·05 = 2·6 tons/acre.

P = 0·1 = 3·6 tons/acre.

P = ·001 = 4·9 tons/acre.

46106/26 was infected with mosaic, but despite this outyielded the other varieties under trial. 46106/27 outyielded all varieties except 46106/26 and showed a high level of resistance to mosaic as also did the remaining varieties under test.

Variety Trial II

Three of the higher yielding Amani Hybrids were compared with a local variety of cassava at Msabaha. The design was randomized blocks of 1/40th acre plots. The spacing used was 5 ft. x 3 ft. and the trial was harvested after 11 months. The yields are given in Table II.

Table II—Yields of Cassava Root in Tons/Acre

Variety ..	46106/26	46106/27	4697/4	Local	S.E.	L.S.D.
Yield ..	8·2	10·2	4·9	1·7	±0·86	2·96

The Amani Hybrids gave much higher yields than the local variety. The trial was exposed to a high incidence of mosaic infection and all varieties exhibited mosaic symptoms. These were less severe on 46106/27 and 4697/4 than on the local variety and 46106/26.

Ridging Trial

A trial was planted at Vuga on heavy shale soils in August, 1958, to compare the effects of three different sizes of ridge, 3 ft., 4½ ft. and 6 ft., and flat cultivation on yields of cassava, variety 46106/27. The design was randomized blocks with 1/40th acre plots and the plots were split for an application of farmyard manure at 5 tons/acre. No significant responses to treatments were obtained. The trial was harvested in 1959 and a mean yield of 5.23 tons/acre obtained.

Cotton

Variety Trial

A trial to compare four cotton varieties, U.K. 51, U.K. 58, N.C. and Ilonga commercial, was planted at Msabaha. The design was randomized blocks and the plot size was 1/80th acre. Cultivation was on the flat and the spacing used was 3 ft. x 1½ ft. Yields were high and are given in Table III.

Table III—Yields of Seed Cotton in Lb./Acre

Variety ..	UK 51	UK 58	NC	IC	SE	L.S.D. P=·05
Yield ..	1,032·8	1,187·2	929·9	1,038·5	±59·39	175·8

U.K. 58 was the highest yielder. It carried fewer but larger bolls than U.K. 51 and exhibited a high degree of resistance to attack by Jassids. The N.C. and I.C. varieties yielded well and matured earlier than the U.K. varieties but showed no Jassid resistance.

Ridging Trial

On the heavy shale soil at Vuga a trial was planted to compare the effects of 6 ft. x 3 ft. ridges and flat cultivation on yields of cotton. The variety used was U.K. 51. The design of the experiment was randomized blocks of 1/80th acre plots and the spacing used was 3 ft. x 1½ ft. The plot yields were very variable and the treatment differences narrowly failed to reach significance. The yields are given in Table IV.

TABLE IV—YIELDS OF SEED COTTON IN LB./ACRE

Flat	3′ ridges	6′ ridges	S.E.	L.S.D. p=·05
563·4	843·2	1,035·1	±203·7	618·3

Fertilizers

MAIZE FERTILIZER TRIAL

The 2^5 factorial fertilizer trial at Msabaha, reported on in detail in last year's report, was cropped with maize this year, and treatments A, ¾ cwt./acre of urea, D, 20 lb./acre of manganese chloride, and E, a trace element mixture containing zinc, boron, molybdenum and copper, were reapplied. The maize was planted at 3 ft. x 1 ft. Yields were poor and the only significant response was to the application of urea as a top dressing. The yields are given in Table VI.

TABLE VI—YIELD OF MAIZE GRAIN IN LB./ACRE

Treatment ..	¾ cwt. of urea	Nil	S.E.	L.S.D. 0=·01
Yield	1,062	876	±43	130

Manure

In 1957 a trial was planted on the Shimba Hills Settlement Scheme to test the effects of farmyard manure and phosphate on crop yields. The design was a 3^3 factorial in one replicate. The plot size was 1/40th acre. In 1957 double superphosphate was applied at the rate of nil, 1 cwt. and 2 cwt./acre and farmyard manure was applied at nil, 5 tons and 10 tons per acre. In 1958 a further dressing of farmyard manure was given at the rate of nil, 2½ tons and 5 tons per acre. The results are given in Tables VII, VIII and IX.

TABLE VII—THE EFFECTS OF PHOSPHATE—YIELDS IN CWT./ACRE

Season	Crop	YIELDS OF GRIAN			S.E.	L.S.D.	
		Nil	1 cwt. supers	2 cwt. supers		5%	1%
LR 1957 ..	Maize	4·44	6·03	5·23	±0·49	1·05	1·45
SR 1957 ..	Green Gram ..	3·71	4·44	4·66	±0·27	0·58	0·80
LR 1958 ..	Sorghum ..	7·89	9·77	8·77	±0·60	1·81	2·50
SR 1958 ..	Green Gram ..	1·99	2·33	2·44	±0·13	0·41	0·56
LR 1959 ..	Maize	17·20	18·70	18·00	±1·40	4·20	5·82

Significant responses to phosphate were obtained for the first four seasons. 2 cwt./acre of double superphosphate gave no increase in yield over 1 cwt./acre.

TABLE VIII—EFFECTS OF FARMYARD MANURE APPLIED IN 1957
YIELDS IN CWT./ACRE

Season	Crop	Yields of Grain			S.E.	L.S.D.	
		Nil	5 tons FYM	10 tons FYM		5%	1%
LR 1957 ..	Maize	4·60	5·08	6·03	±0·49	1·05	1·45
SR 1957 ..	Green Gram ..	3·78	4·39	4·57	±0·27	0·58	0·80
LR 1958 ..	Sorghum ..	8·06	8·62	9·75	±0·60	1·81	2·50
SR 1958 ..	Green Gram ..	2·03	2·22	2·41	±0·13	0·41	0·56
LR 1959 ..	Maize	17·72	18·33	17·96	±1·40	4·20	5·82

Significant responses to farmyard manure were obtained during the first year only.

TABLE IX—EFFECTS OF FARMYARD MANURE APPLIED IN 1958
YIELDS IN CWT./ACRE

Season	Crop	Yields of Grain			S.E.	L.S.D.	
		Nil	2½ tons FYM	5 tons FYM		5%	1%
LR 1958 ..	Sorghum ..	6·29	9·26	10·88	±0·60	1·81	2·50
SR 1958 ..	Green Gram ..	2·07	2·14	2·65	±0·13	0·41	0·56
LR 1959 ..	Maize	16·12	18·91	18·97	±1·40	4·20	5·82

Significant responses to farmyard manure were obtained for one year only.

Maize

VARIETY TRIAL

Eight varieties of maize were planted in duplicated observation plots at Mtwapa. The plot size was 1/40th acre and the plants were spaced at 3 ft. x 1 ft. One cwt. per acre of sulphate of ammonia was applied as a top dressing. The yields are given in Table X.

TABLE X—YIELDS OF MAIZE GRAIN IN BAGS/ACRE

Variety	Yield	Variety	Yield
Tanag I (Dent)	12·08	Tanag I (Flint)	8·23
Nyanza Bulk	4·60	Taboran	5·61
Local White	13·51	Tanag II (Dent)	7·42
Polysora Resistant Maize ..	12·83	E.M.W.S.	8·09

The local maize was the highest yielder followed by the Polysora Resistant maize bred at the Coast. The variety Taboran was ready for harvesting three weeks before the others.

Maize Spacing Trial

A trial comparing six different spacings of maize and three different plant populations was planted at Mtwapa. The design of the trial was randomized blocks with plots 1/27th acre in size. All plots were given 1 cwt./acre of sulphate of ammonia as a top dressing. The yields are given in Table XI.

Table XI—Yields of Maize in Bags/Acre

Spacing	Plants/Hill	Plants/acre	Bags/acre
3′ x 1′	1	14,520	16·05
3′ x 1½′	1	9,680	13·38
3′ x 1½′	2	19,360	14·61
3′ x 2′	2	14,520	15·06
3′ x 3′	2	9,680	10·43
6′ x 9″	1	9,680	4·68

S.E. = ±0·68 bags/acre.

L.S.D.	p 0=·05	p 0=·01	p=·001
	1·50	2·07	2·86

Very poor stands were obtained at the spacing of 6 ft. x 9 in. All the plants which germinated died and this treatment was replanted 10 days after the initial planting date. The yields of treatments with a plant population of 14,520 did not differ significantly and outyielded all other treatments except the one with 19,360 plants/acre.

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G.P.K. 2668—680—9/60

Printed
by
the
GOVERNMENT PRINTER, KENYA